SLIP

THE ELECTRIC LIGHT IN AMERICA.—It is stated that Kalamazoo, Mich., is to be lighted on the Brush system.

NEW CABLE ACROSS THE FIRTH OF FORTH.—A new cable is being laid across the Firth by the Post Office in the neighbourhood of Burntisland.

DIVIDEND.—The Western Union Telegraph Company has declared a quarterly dividend at the rate of 6 per cent. per annum, payable January 16.

A CONUNDRUM.—Why will the catalogue of the forthcoming Electrical Exhibition be remarkably short? Because it will be commenced and finished under one Page.

ROYAL SOCIETY.—The following paper was to be read on Thursday last before this society—viz., "Manometric Experiments in the Electric Arc," by Professor Dewar, F.R.S.

ELECTRICITY AND MAGNETISM.—Mr. James Mason was to have delivered a lecture on this subject before the Birmingham Architectural Association, on Tuesday last, the 17th inst.

THE TELEPHONE IN CEYLON.—Negotiations for the establishment of a telephone exchange were, according to recent news, proceeding at Colombo on behalf of the Oriental Telephone Company.

ELECTRIC LIGHT IN PHILADELPHIA.—It is stated that the substitution of the electric light for gas in the Philadelphia Post Office has effected a saving during the past year of over 6,000 dollars.

ELECTRIC LIGHT ON RIVER STEAMERS.—The steamers on the Mississippi, which are best known from their liability to boiler explosions, are said to be fitted with electric lights to some considerable extent.

THE "RETRIEVER."—This cable ship, which is doing repairs for the West Coast of America Telegraph Company, was expected at Callao on the 14th inst., to commence work sounding to the northward.

ENGLISH TELEPHONES FOR ABROAD.—It is stated that Messrs. Harrison, Cox, Walker and Co., of Darlington, have executed an order for 100 of their telephones (the Hummings) for the Italian Telephone Company.

THE ELECTRIC LIGHT ON MEN-OF-WAR.—Orders have been received at Chatham, directing that the "Ajax" and "Agamemnon," turret ships, are not to be fitted with the electric light pending the final determination of the Admiralty.

CAPE COLONY.—According to the revenue returns for the month of October last the receipts from the telegraphs of the colony for that month amounted to £5,420, against £3,692 for the same month of 1880, or an increase of £1,728.

EXCHANGE TELEGRAPH COMPANY.—We learn that this company is about to introduce the telephone for the use of its subscribers, to supplement its present system of telegraphic inter-communication. The Gower-Bell instrument will be used.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this Company for the week ending 13th January, were £2,462, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

ELECTRIC LIGHT FOR EXETER.—A proposal from a private company to light Exeter by electric light has been referred to the Streets Committee of the Town Council. It is proposed to utilise water power, of which there is abundance in the neighbourhood.

THE ELECTRIC LIGHT AT CAPE TOWN.—The use of the electric light has, we believe, been temporarily suspended at the Cape Town Railway Station, owing to a dispute on the question of cost, but the public is in favour of the continuance of the contract.

NEW AMERICAN TELEGRAPH COMPANY.—A new undertaking has been organised at New York, under the title of the Postal Telegraph Company. The object is to build and equip a line to Chicago, and one million dollars have been subscribed for the purpose.

THE "DACIA."—The India Rubber, Gutta Percha, and Telegraph Works Company have received information of the safe arrival of the ss. "Dacia" at Valparaiso on the 11th inst., and that she left for Callao on the 12th. This arrival at Valparaiso is four days under the estimated time.

SWAN LIGHTS ON CABLE SHIPS.—Mr. W. F. King, engineer-in-charge of the India Rubber Company's ss. "Dacia," reports from Rio Janeiro, under date December 19th, that the Swan lights on board have given so far great satisfaction, and give a beautiful and steady light in the saloon.

POST OFFICE TELEGRAPHS.—An open competition for admission to the Post Office (Male) School of Telegraphy (aged 14 to 18) will be held in London on February 9. For particulars and the necessary form of application apply at once to the Secretary, Civil Service Commission, London, S.W.

NEW TELEPHONE COMPANY.—The formation of a new company, under the title of the Telephone Supply Company, has been made public. It has a capital of £50,000 in £10 shares, and its object is to erect, maintain, and work telephone lines. It will not manufacture the instruments, however.

TELEGRAPHIC EXTENSION IN BRITISH COLUMBIA.—The *Colonies and India* says that the estimate for a line of telegraph from Port Townsend to Cape Flattery is only 25,000 dollars. Our contemporary also remarks that its construction will afford the greatest possible aid to shipping in Puget Sound.

NEW ELECTRIC LIGHT COMPANY.—The Laing Electric Light and Power Company is announced with a capital of £1,000,000, in shares of £10 each. Its objects are stated to be to acquire and work the patents in connection with the Laing system of electric lighting. The offices are at 12, King William-street, E.C.

THE EDISON LIGHT.—On Tuesday night at the Crystal Palace, and on Wednesday night at Holborn, the Edison light was shown on a large scale in action. As it is our intention to give complete details of these installations, it is not necessary for us to say more now than that these experiments were successful.

TELEGRAPHIC COMMUNICATION WITH HOSPITALS.—At a meeting of the St. John Ambulance Association held early in this week, a resolution was passed in favour of placing those metropolitan police stations not so connected already in electrical communication for ambulance purposes with the hospitals and with one another.

THE TELEPHONE IN PLYMOUTH.—At a meeting of the Plymouth Chamber of Commerce held recently, a resolution to the effect that licences to open telephonic exchanges ought to be granted without preference or limitation to all applicants of whose *bona fides* and responsibility the Post Office were satisfied, was put but was negatived.

OVERHEAD WIRES AT SHEFFIELD.—The passage of a fire escape to the scene of a fire having been somewhat delayed a

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short time since, at Sheffield, owing to its having to be lowered several times to pass under the various overhead wires, the Town Council have decided that the height of such wires from the ground must be considerably raised.

THE LOWESTOFT CABLE AGAIN BROKEN.—The Indo-European Telegraph Company notify that owing to another breakage which has occurred in the Lowestoft-Norderney cable, belonging to the Post Office, the company's direct wire to India and beyond is interrupted between England and Germany. Their line is working, as usual, however, between the Continent and India.

TELEGRAMS TO RUSSIA.—At the monthly meeting of the Hull Chamber of Commerce on the 10th inst., attention was directed to the cost of telegrams from this country to Russia, viz., 9d. per word, whereas telegrams from Germany, Belgium, and France to Russia cost only 3d. to 4d. per word. The consideration of how best to obtain a reduction was adjourned to the next council meeting.

EXPORTS.—The value of the telegraphic wire and apparatus connected therewith exported from the United Kingdom during the month of December last amounted to £21,146, against £91,700 for the same period of 1880, and £20,660 in 1879. The values of the exports of the same articles for the years 1879, 1880, and 1881 were respectively in the order given £2,500,637, £1,300,908, £1,974,266.

THE ELECTRIC LIGHT AT LISBON.—The Electric Light has played a prominent part in the illuminations on the occasion of the meeting of the Spanish and Portuguese kings, which has taken place within the last few days. The Exhibition Gardens at Janellas Verdes were lighted by this means, as was also the North Bank of the Tagus, from Lisbon to Belem. In the latter case, both gas and electricity were used.

VESTED RIGHTS.—The Town Council of the town of Fond du Lac, Wisconsin, U.S.A., having resolved to adopt the electric light, have been given notice by the local gas company that they claim a vested right to light the city, and will seek to enforce their rights. A remonstrance against making the experiment of the electric light, signed by some of the heaviest taxpayers in the city, has also been presented to the Council.

THE ELECTRIC LIGHT FOR DARLINGTON.—The question of the formation of a company to introduce the electric light into the business and domestic establishments in Darlington was discussed at a meeting held last Friday in that town. Mr. Cox-Walker, of the firm of Harrison, Cox-Walker, and Company, of Darlington, gave an interesting descriptive *resumé* of the subject of lighting by electricity, after which the meeting was adjourned.

THE ELECTRIC LIGHT AT TRENTHAM HALL.—The Duke of Sutherland, says a provincial contemporary, has given notice to the Gas Committee of the Stoke-on-Trent Corporation to terminate the supply of gas to Trentham Hall, with the view of adopting the electric light at his Staffordshire seat at an early date. The Duke is the largest gas consumer in Staffordshire, and for some years past has been supplied at 6d. per 1,000 cubic feet less than the general public.

THE ELECTRIC LIGHT IN OLDHAM.—Messrs. Platt Brothers and Co., a large cotton machinist firm of Oldham, have determined to try the electric light in some rooms at their extensive works at Werneth. It is expected that the preparations for placing the new light in operation will be completed in about a fortnight. It is stated that Messrs. Platt Brothers and Co. are the largest consumers of gas in the borough. We believe that several other large firms have the matter under consideration.

ASSOCIATION OF CHAMBERS OF COMMERCE.—At the annual meeting of this association, which begins on the 28th February next, it will be proposed that a deputation be appointed to wait on the Postmaster-General, in order to impress upon him the desirability of the Government entering into negotiations with foreign countries for the purpose of cheapening and facilitating telegraphic communication. It will also be proposed to present him with a memorial urging the desirability of laying the telegraph wires in the country underground.

CIPHER TELEGRAMS PERMITTED IN SPAIN.—The *Official Gazette* of the 13th instant publishes a Royal decree permitting the use of secret cipher in private telegrams both in Spain and for abroad. It is accompanied by a statement explaining the reasons why this step has been taken, namely, that the Government wish to remove the obstacles which at present interfere with the despatch of private messages, and also desire to follow the progressive tendencies of the rest of the civilised world. It is stated that the measure has caused great satisfaction at Madrid.

A USE FOR THE PHONOGRAPH.—*L'Electricité* says that a curious application of the phonograph is announced from a northern town. Two merchants, whose offices were connected by a telephone line, established a phonograph in a shunt circuit, which, being set in action when the business had been transacted by the wire, was capable of repeating the words that had been exchanged, thus giving them all the weight of a written communication. Our contemporary concludes by saying that the most astonishing fact connected with this piece of news is that the idea did not emanate from the banks of the Thames or Mississipi.

INTERNATIONAL LEGISLATION FOR SUBMARINE TELEGRAPHS.—In consequence of the wish expressed by the Congress of Electricians, the French Government have decided to address to the Maritime States a proposal to hold a Diplomatic Conference for the purpose of settling the questions of international law in regard to submarine telegraphy. The question has been taken up very warmly on the other side of the Channel in the columns of our contemporary, *L'Electricité*. Whilst glad to chronicle this step in the right direction, we may be permitted to express the hope that the conference will not be confined to diplomats, but that practical persons intimately connected with submarine telegraphy will have a voice in the matter.

ELECTRIC LIGHT AT MILFORD HAVEN.—On Monday night the large promenade facing the new Milford Docks was most successfully lighted up by the British Electric Light Company with one of their Gramme machines and five powerful Brockie electric lamps. The effect was pronounced by all who saw it to be most satisfactory, the light being remarkably steady and brilliant. This lighting is the first part of a greatly extended system to be adopted in illuminating the whole town, harbour, and new pier, recently erected for the accommodation of transatlantic steamers. The installation created a great sensation in the district, and nearly the whole population turned out to witness the display, the local band (taking advantage of the central light on the promenade) playing a large selection of music in honour of the event.

THE ELECTRIC LIGHT AT LIEGE (BELGIUM).—The wool factory of MM. Closset and Begne, of Liege, has for some time past been lighted up by means of the Jaspar electric lamp, the inventor of which, M. Jaspar, is also a native of Liege. The saving effected by the use of this light instead of gas is remarkable, even when we take into account the high price of gas in Belgium. *L'Industrie Belge* says that

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a cubic metre of gas costs 32 centimes at Liege, which would bring the cost of the ordinary rate of consumption to 5 centimes per hour, or, for thirty burners, 1·50 franc per hour. Against this we have the carbons of the electric lamp, which last four hours, and cost 60 centimes the pair, or just 1-10th the cost of the thirty gas burners for the same time. The lights are run with a Gramme dynamo machine.

The Swan Light at Birmingham.—At a recent *conversazione* at the Birmingham and Midland Institute a splendid display was made by Swan lamps shown by the Swan Electric Light Company of Newcastle. In the lecture theatre some fifty-five lights were shown. Some being arranged on a central chandelier which could be raised or lowered whilst the lamps were alight as required, and others on side brackets, as portable table lights, &c. This light has also been introduced into the refreshment room at the Town Hall, and, according to the *Birmingham Daily Post*, the result is very pleasing. Our contemporary says, "The electric light in this room is not turned on until half-past nine; and it is an interesting fact that, in a short time, air which previously is oppressive from the burning gas becomes sensibly cooler and fresher." This is an interesting fact which we think is incontrovertible.

Extension of Telephone Exchanges.—The British and Irish Telephone and Electric Works Company have been refused a license to establish telephone exchanges in twenty of the largest towns in England by the Postmaster-General on the following grounds, viz., that "it is now generally recognised that it is not for the public interest that several rival exchanges should be established in one town, an important condition of the exchange system being that every subscriber should be able to communicate with every other subscriber. Although, therefore, the Postmaster-General has carefully guarded himself from making any of the licenses which he has granted exclusive, yet, in view of the general satisfaction which, so far as he is aware, is being given by the existing telephone companies, and the absence of complaint or remonstrance to himself from the communities concerned, he does not feel called upon to grant further licenses."

The Electric Conductivity of Gases.—M. Zumakion has made experiments in this direction. He caused the discharge from a condenser to traverse a tube filled with gas and a Reiss thermometer. He began by noting the rise of the thermometer on closing the circuit, without producing a spark, by means of one of M. Alvergniat's vacuum tubes, one electrode of which was movable and touched the other when the tube was turned. He then repeated the experiment after having introduced a tube of known dimensions, filled with air, hydrogen, or carbonic acid, at a variable pressure. The total quantity of heat produced in the circuit by a similar charge of the condenser is constant; it is distributed between the metallic conductors and the gases according to their respective resistances. The specific resistance of carbonic acid is greatest, that of air is less, and of hydrogen less still. The resistance of a column of gas is nearly proportional to the length of the spark.

Electric Lighting.—This was the subject of a recent lecture by Mr. H. P. Holt, before the Leeds Architectural Society. The lecturer commenced by describing some of the leading systems of electric lighting. Speaking of the Bürgin machine, he said that it was coming largely into use, principally on account of its simplicity of construction. He then alluded to some public places where the electric light had been adopted with advantage. At the Alexandra Palace there were formerly 2,000 gas lights, which cost 26s. per hour. These had been replaced by six Crompton lamps, worked by a Bürgin machine, the cost being 6s. per hour. It should be borne in mind, however, that that building, being very high, was particularly adapted for electric lighting. At King's Cross Station the cost of electric lighting was 6s. per hour, as against 24s. for gas, the illuminating power of the former being perhaps double that of gas. Mr. Holt stated that he had fixed apparatus for the electric light at his own house, but the experiment being on a small scale, he of course found it an expensive one. Entering into a further comparison of the cost of the respective systems of lighting, he showed that where the cost of 48 gas burners would be 1s. 1¼d. per hour, the cost of a Swan lamp, which would burn on an average 500 hours, would be 1s. 4d., though he pointed out they would be able to obtain 30 per cent. more light for the 1s. 4d. than for the 1s. 1¼d. A great difficulty, especially with the incandescent lamps, was in securing regular motion. He considered that one of the simplest ways of getting over that difficulty was to have a heavy fly-wheel.—Mr. William Howgate, in proposing a vote of thanks to the lecturer, referred to the inconvenience which was experienced with the electric light in places where there were projections, owing to the shadow which was cast. He mentioned that in a building in Leeds where the electric light was adopted a large amount of gas had to be used so as in some measure to obviate that difficulty.

Electric Lighting by Incandescence.—On Monday last an interesting paper on this subject was read before the Royal Society of Dublin by Mr. J. Angelo Fahie, C.E. The author said that the electric light might be briefly described to be the result of the following operations:—First, the conversion of the energy of heat stored up in coal into energy of motion, which is accomplished with the aid of a steam engine; secondly, the conversion of the energy of motion into electrical energy, which is done by the dynamo machine; and thirdly, the conversion of electrical energy into light, which process is fulfilled by the electric lamp. He then stated that there were three kinds of lamps—"arc," "semi-incandescent," and "incandescent," and proceeded to describe the difference in construction of each kind. Having referred to the early experiments of King, Staite, and Swan with the incandescent lamps, he then passed to those of Edison, Maxim, and Lane-Fox, describing the improvements introduced by each of these well-known inventors into his particular system. Mr. Fahie said that there was no question as to the satisfactory results afforded by incandescent illumination. The light is mellow and steady in its character; brilliant, yet free from the glare of its bigger brother, the arc; clear, yet not trying to the complexion of the fair who may come within range of its influence. As to the question of expense in applying incandescent lighting, it must be borne in mind, Mr. Fahie said, that the whole system of electric lighting is yet in its infancy, and it would, therefore, be unfair to enter dogmatically into comparisons between its cost and that of the older established means of lighting by gas. As to his recent attempt to light the Royal Dublin Society's rooms with Swan lamps, it would, he said, be misleading to form any estimate of the expense, having regard to the limited nature of the experiment. His non-success, however, was not owing to any deficiency in the necessary elements for providing a good steady light, but to expense alone. He had gained experience enough to convince him that the system, when it could be applied on a large scale, could be worked with economy and efficiency, and could not fail to gain in public favour. At the conclusion of the paper a short discussion followed.

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ON THE THEORY OF MAGNETO AND DYNAMO MACHINES.

VI.

The last two articles have seemed to some, we fear, unpleasantly mathematical, though really it is more in appearance than in fact. It had been our intention, and still is, to avoid the use of symbols and technicalities whenever possible; and, though we have been constrained in this very important part of our subject to introduce a trace of differential notation and processes, we will try to illustrate the meaning of it a little, and also to put the main ideas into a more popular form. And first consider an analogy.

A mass m placed in the earth's gravitation field of force has a certain amount of potential energy, $E = m\,g\,h$, and is urged downward with a certain force proportional to $\frac{d\,E}{d\,h}$, the expression for the rate of change of energy per unit of vertical displacement. That is, $F = \frac{d\,E}{d\,h} = m\,g$, the well-known expression for the weight of a body.

The fact that a body experiences this gravitation force is at present an unexplained one; all we can assert, without dogmatising in the least, is that it is immediately due to some peculiarity in the region of space or medium in immediate contact with it, a peculiarity which can be expressed numerically, which varies with the height above the earth, and which urges the body down by reason of a difference in its value above and below the body.

There is, then, a *something* in the medium, or in space, to variations in which the gravitation force on matter is due; and the intensity of force in any direction must be proportional to the rate at which this something changes per unit of distance in that direction. Call this something V, and the intensity of force, or force per unit of mass, call f, or $\frac{F}{m}$; and take a small change of position in any direction, which you call $d\,h$. Then the something V is defined by the equation $f = \frac{d\,V}{d\,h}$. But we know that in the downward direction $f = g$; therefore, reckoning from a convenient zero, $V = g\,h$.

Now, the potential energy of a mass m, at a height h, is $m\,g\,h$; therefore $g\,h$ is the potential energy of unit mass; and we may say that the value of V at any point is the potential energy which unit mass would have if placed there. V is a measure of the peculiar property of the medium at every point (a property which is certainly induced by the earth, but whose nature is quite unknown), and it is called the *gravitation potential.*

Again, consider a weightless body of bulk u, immersed to a depth h, beneath the surface of a liquid of density ρ. It is forced upward with a force $u\,g\,\rho$, and it has potential energy equal to the work it can do in ascending, viz., $u\,g\,\rho\,h$.

The force is due to some peculiarity in the medium, which has a different value under the body to what it has above, and the intensity of force in any direction is proportional to the rate of variation of this something per unit of distance in that direction. Call this something p, and the intensity of the force, or force per unit of volume, call f or $\frac{F}{u}$; then, if we take a small displacement horizontally, there is no change in p, and consequently no f; but, if we take it vertically, and equal to $d\,h$, $f = \frac{d\,p}{d\,h}$; and this equation defines the unit of p.

But we know that $f = g\,\rho$; therefore, reckoning from a convenient zero (the surface of the water),

$$p = g\,\rho\,h.$$

The value of p at any point is the potential energy of unit volume (supposed weightless) if placed there; it is a measure of the peculiar property of the medium at every point (a property which we imagine ourselves to understand far more about than we do about the gravitation property), and it is called the *hydrostatic potential*, or more simply the *pressure.*

All this is childish unless understood as allegory, but it is precisely as allegory that we wish it to be understood.

Consider, now, a magnetic pole at a certain point in a magnetic field. There is a peculiar property in the field which varies from point to point, and to the variation in which the force experienced by the pole is due. This something is called *the magnetic potential* at the point, and it is defined to be equal to the potential energy of a pole of unit strength in that position.

We do not know what the property is; when we do, perhaps, we will call it "pressure" or some name that general custom has made us feel as if we understood.

If this property is induced by the neighbourhood of a number of magnetic poles m_1, m_2, ... at distances from the given point r_1, r_2, . . . then the potential at the point is known to be $\frac{m_1}{r_1} + \frac{m_2}{r_2} + \ldots$ or simply $\Sigma\,\frac{m}{r}$. [It is the same with electricity, substituting for m quantity of electricity; it is the same with gravitation, substituting for m quantity of matter; it is the same with anything where the force acts in the direct joining line, and varies inversely with the square of the distance.]

If, however, the property be induced, not by magnets but by currents—if it be due to a current circulating in a closed circuit in any position whatever—then, to express the potential at any point, imagine your eye there and see how big the circuit looks (not knowing or not caring for its distance, and, therefore, not knowing or not caring for its actual size in square inches), that is, see how great an angle it subtends at your eye. Whatever the shape of the circuit, a cone—not in general a *circular* cone, of course—can always be drawn, having your eye (or the given point) as vertex, and the circuit as base; and the angle of this cone is what you want. You may not know how to express its value numerically, but you can always estimate it to yourself. Well, the potential at the point is exactly proportional to this solid angle. It is also proportional to the strength of the current circulating in the circuit; therefore, it is proportional to the *product* of the strength of the pole and the solid angle.

To say that it is *equal* to this product is virtually defining the unit strength of current; but, as we had not already defined it, there was no objection to this definition, and, as it has the advantage of being the one now employed all over Europe, we so defined it, saying, in symbols,

$$V = \gamma\,\omega.$$

We here suppose that there is only one circuit and that the current goes round it only once. Suppose, however, that the circuit is a coil of wire of n turns (the shape of the coil being still arbitrary). Then the solid angle subtended is virtually multiplied by n, and the above remains true; but if ω stand merely for the angle subtended at any point by the mean turn of wire on the coil, then the whole potential at the point is $n\,\gamma\,\omega$.

If instead of one coil there are any number of coils scattered about space, the process has to be applied to each in succession, and their potentials added up; so that in general the magnetic potential at a point is $\Sigma\,\gamma\,\omega$.

If we place a magnetic pole at the point it will have potential energy E equal to $m\,\gamma\,\omega$ for each circuit.

The force urging the pole to move in any direction $d\,x$ will be $\frac{d\,E}{d\,x}$ or $m\frac{d\,V}{d\,x}$, that is $m\,\gamma\,\frac{d\,\omega}{d\,x}$; or, in other words, the intensity of magnetic force in any direction is simply proportional to the rate at which the solid angle subtended by the circuit would increase if you went at unit speed in that direction.

The physical meaning of the solid angle which a circuit subtends is nothing else than the number of lines of force threading the circuit. For the number of lines due to a pole which thread a given contour will be obviously proportional to the solid angle which that contour subtends at the pole. In other words, you will have a cone-full of lines, the cone having the pole as vertex and the contour as base.

Hence we may restate the matter thus:—The potential at

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a point, produced by a circuit, is equal to the strength of the current multiplied by the number of lines of force which unit pole placed at the point would send through the contour of the circuit. [*i.e.*, would send through the circuit before the current began to circulate; any alteration in the distribution of lines *produced by the current itself* is not to be reckoned.]

Turning our attention from the action on the pole to the reaction on the circuit, we need merely say that the potential of a circuit due to a pole is equal to the strength of the pole multiplied by the same solid angle as before, viz., the angle subtended by the circuit at the pole. Or, again, it is simply the number of the pole's lines of force which thread the circuit.

The potential of a circuit means its potential energy when conveying a unit current, and the rate at which the potential energy changes for any displacement (translation or rotation) as you carry on that displacement with unit velocity (translational or angular), is equal to the force (or the couple) tending to produce such displacement.

And now that we have put it all over again we fear we have been long-winded. But it is a very important matter, and one that might be more widely understood than it is, and if we have not made it clear it has not been for want of trying.

It may be useful to state that the solid angle subtended by a whole sphere, or any other closed surface at any point inside it, is numerically equal to 4π. The angle subtended by the sky at a point on the sea is 2π. The angle subtended by any plane contour at any point quite close to its plane is also 2π. The solid angle of a circular cone, the angle of whose axial plane section is 2θ, is 2π vers. θ. Thus, if a circle subtend symmetrically a plane angle of 120°, the solid angle of the cone is π. And, in general, any solid angle is measured by the portion of a sphere of unit radius which is cut off or bounded by the angle, the vertex of the angle being the centre of the sphere.

The number of lines of force sent by any pole through any contour placed anywhere is equal to the strength of the pole multiplied by the solid angle which the contour subtends at the pole.

THE LATE C. L. SCHWENDLER.

Carl Louis Schwendler was born the 18th May, 1838, at Torgau, a fortified town in Prussia, where his father was captain in a line infantry regiment. During his early youth C. L. Schwendler was educated at the High School (Gymnasium). After leaving the High School he entered the Technical College (Gewerbe Institut) of Berlin. His kind and jovial manners and great ability, especially in mathematics, soon made him the favourite of the institute, and his assistance in their mathematical studies enabled many of his college friends to keep pace with the teachings of the professors.

On leaving the institute he obtained employment at the already celebrated firm of Siemens and Halske, in Berlin, where, curiously enough, he was, at first, put to work at the anvil, probably on account of his robust build and physical strength. His superior mental abilities were, however, soon noticed, and he found himself, in a few days, assisting Dr. Werner Siemens in his laboratory, together with Dr. Esselbach, Robert Sabine, and others, in determining the Siemens unit and the carrying out of many other scientific researches.

He was, in May, 1861, engaged by the firm to carry out experiments upon the Malta-Alexandria cable. When the branch business, "Siemens, Halske, and Co.," who had started as telegraph engineers some years previously in London, found it necessary to manufacture their own submarine and subterranean cables, it was Mr. C. L. Schwendler who was deputed by the mother firm in Berlin to arrange the electrical part of the undertaking. He was chief electrician during the manufacture and the laying of several cables for the French Government in 1863 and 1864, in which latter year he was struck down with typhus fever at Oran. His strong constitution, however, soon enabled him to shake off the fever. He continued superintending the electrical branch of the Siemens cable works until 1868, when Colonel Robinson, at that time the Director-General of Telegraphs in India, found he required some electrician of experience to organise the system of Government telepraphs in India. He introduced into the Indian Telegraph Department a complete system of electrical testing, and compiled one of the best books we have on the subject for the special purpose of giving exact knowledge, so that there could be no excuse for remissness in the performance of the duties required by the department. This book was subsequently published in England.

Mr. Schwendler was recommended by his firm, and accepted provisionally as assistant electrician to the Director-General of Telegraphs in India early in 1868, and remained in that position as an *employé* of the firm of Siemens Brothers until the commencement of 1870. Highly appreciated for his integrity, ability, and kindliness by the whole staff, he was offered by his chief a high position in the Government service, which he accepted at the commencement of 1870, and which he held and the duties of which he fulfilled to the satisfaction of the administration. He carried out a number of original experiments, the results of which are to be found in various papers in the *Transactions* of the Asiatic Society, in the *Philosophical Magazine*, &c. Within the last few years, and particularly while in England two or three years ago, he carried out a series of elaborate experiments in connection with electric lighting, of which an admirable report was given. Upon his return to India he paid close attention to the use of the currents from dynamo machines for telegraphic purposes. The results of these experiments have often been referred to, and in another part of this issue we give the details of his latest experiments. Although of robust constitution, the treacherous climate of India gradually undermined his health, and the work on the north-eastern frontiers, entrusted to him by the successor of Colonel Robinson, sufficed entirely to destroy it. On a sixteen months' sick leave for Europe he arrived at Brindisi in July last, shattered in health, both mentally and bodily. His aged mother had to come from Dresden to take him home by easy stages. On his arrival there he entered a celebrated hydropathic institute, in the neighbourhood of Dresden, with little benefit. He was then removed to the Maison de Santé, at Schoeneberg, near Berlin, a sanitary institution of the highest renown, where he seemed to rally up to Christmas last, but rapidly sank shortly after, and finally expired suddenly on Friday, the 6th instant, in a paralytic fit.

His remains were interred on Monday, the 9th instant, in the quiet village churchyard of Schoeneberg, near Berlin, followed by a multitude of college friends of his youth and professional admirers, and bewailed by his aged mother, whose mainstay he had been all his lifetime.

THE USE OF DYNAMO MACHINES IN TELEGRAPHY.*

BY LOUIS SCHWENDLER, M. INST. C.E.

In a previous experiment the dynamo-electric machine was placed at the store-yard, Howrah, and driven by the store-yard engine. The current was conveyed to the Calcutta Telegraph Office by the store-yard line, which is about four miles in length. This first trial proved so successful that I ventured to propose a larger trial to supply *all* the lines entering the Calcutta Telegraph Office with signalling currents derived in this manner. But I could not then execute the new trial, as in the first place there were no proper driving arrangements at the store-yard (the erection of these would have cost money), and in the second place the dynamo-electric machine at my disposal had, by an accident, been temporarily spoiled. It was thought advisable, therefore, to postpone the suggested trial on a larger scale until the electric light arrangements at Howrah should be completed, when an easy opportunity would offer itself for trying different dynamo-electric machines for the purpose. Besides, telegraph lines being already up between the Howrah Railway Station and the Calcutta Telegraph Office, no additional expense would need to be incurred.

New trial on a larger scale.—The preliminary trial was instituted on the 28th August, the final one on Sunday the 29th August, 1880.

In the accompanying diagram, m is the dynamo-electric

* From a Report to the Director-General of Telegraphs.

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machine which produces the main current to be made use of for any required purpose; the negative pole of the dynamo-electric machine is connected permanently to earth. The earth consists of three copper plates* joined parallel and offering a parallel resistance of 1·67 ohms.†

T is a tangent galvanometer for measuring the main current. In this case it was the tangent galvanometer employed in my electric light experiments in London in 1878. The resistance of the copper ring of this instrument is *nil*. Taking the late Mr. Brough's value for H, the horizontal component of the earth's magnetic intensity at Calcutta to be H = 0·37158 dynes, the formula for calculating the currents *c* from the deflections observed by this tangent galvanometer is :—

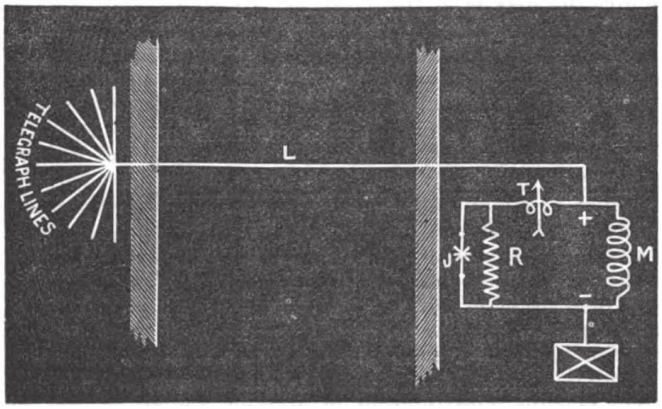
$$c = 47330 \text{ tang } a \text{ (milli-oersted).}$$

r is a coil of iron wire (No. 24 i. w. g., 0·21″ diameter) offering a resistance of 1·517 ohms at 85° F. The wire is coiled on a large wooden drum and serves as the constant resistance by which from time to time the efficiency of the dynamo-electric machine at Howrah can be gauged.

J represents an electric light, in this case produced by a large Serrin-lamp.

In the following experiments, either *r* or *J* was used as the external resistance for closing the poles of the dynamo-electric machine to produce the *main* current; but *never* the *two* joined parallel.

L is the telegraph line from the dynamo-electric machine to the Calcutta Telegraph Office. This line is 1·75 miles in length and consists, from the electric light room to the Howrah Railway Station, of Hooper's india rubber cable core, from the Howrah Station to the Kirk, of No. 6 i. w. g., and thence to the Calcutta Telegraph Office it is American compound wire of the same resistance as iron wire of No. 27 i. w. g.



At the Calcutta Telegraph Office, the *battery wire* could at a moment's notice be connected with the key of each instrument, after throwing off the copper of the signalling battery in ordinary use. The telegraph lines terminating at the Calcutta office were, therefore, all connected *parallel* to the battery wire, as is indicated in the foregoing diagram.

In order to enable me to directly compare the signalling current sent into the lines by batteries and by a dynamo-electric machine, each line is as tested for *sent current* at Calcutta, and for *received current* at the out-station.

Preliminary trial on 28th August, 1880.—The line used for tapping the signalling current was No. 5, Calcutta to Allahabad, 577 miles in length, worked *direct* and having a real conduction resistance of about 3075 ohms (taken from the August, 1880, tests). The resistance of the relay at Allahabad equals 492 ohms.

1*st Experiment.*—This consisted in taking the *sent current at Calcutta* and *the received current at Allahabad* as produced by a battery of 60 Minotti cells connected up in series. This is the usual signalling battery during the monsoon.

2*nd Experiment.*—The main current in this experiment was produced by dynamo-electric machine A through the resistance *r*. The resistance in circuit was not measured, but may be taken to be as follows :—

	$m = 0·652$	internal.	
	$r = 1·517$	ohms at 85° F.	
Leading wire to tangent galv.,	$l = 0·026$	$= 1·543$ external.	
Total	2·195	ohms.	

The main current gave a mean deflection of 37·9°; $\frac{\text{max.}}{\text{min.}} = \frac{39}{36·2}$; mean speed of engine 60·3 revolutions per minute; $\frac{\text{max.}}{\text{min.}} = \frac{62}{58·5}$. The variation of the currents corresponds with the variation of the speed.

3*rd Experiment.*—The main current in this experiment was produced by dynamo-electric machine E through the resistance *r*. This experiment was made in order to see whether A or E machine would suit the circumstances best.

The resistance in circuit was not measured, but may be taken to be the same as given for A. The main current gave a mean deflection of 30·6°; $\frac{\text{max.}}{\text{min.}} = \frac{33·7}{27·0}$; mean speed of engine = 59·9 revolutions per minute; $\frac{\text{max.}}{\text{min.}} = \frac{66}{54}$. The variation of the current corresponds with that of the speed.

The results of the preliminary trial are given in the following table :—

No. Experiment.	Mode of producing the current.	Speed of engine per minute. Mean.	Speed of engine per minute. Max. / Min.	Mean speed per minute of dynamo-electric machine.	Mean of main current in milli-oersteds.	Current in milli-oersteds. Sent at Calcutta.	Current in milli-oersteds. Received at Allahabad.
1	60 Minotti.	...	...	...	9·8	9·8	5·1
2	Dyn. el. machine A.	60·37[8]	62[1] / 58·5[1]	783	36,846	14·5	7·8
3	Dyn. el. machine E.	59·9[6]	66[1] / 54[1]	641	27,991	9·4	6·6

The three experiments were made in the order given. Nos. 2 and 3 were made from 11 to 11·44 hours, during which time messages were sent. The insulation of the battery wire L was variable from 71,000 to 95,000 ohms absolute.

From experiments 2 and 3, it will be seen that A machine produces a larger main current than E, which is due to the higher speed of A; further, that the *sent current* tapped from the main current of A is larger than the *sent current* tapped from that of E, just as it ought to be. In fact, if the line during the two experiments had kept constant, and if also *r* had kept constant (*r* increases considerably by heating), the proportion of the two *main currents* would have been the same as that of the two sent currents, and this is very nearly the case.† No. 3 Experiment with E machine gives about the same result as No. 1 Experiment with battery. To produce the main current by A is therefore more advantageous than to produce it by E. Hence I employed A in the final trial.

The final trial on Sunday, 29th August, 1880.—The battery wire, before the trial began, was tested for insulation, and gave an absolute insulation greater than 1 Ω ohm. The main current, as already mentioned, was produced by dynamo-electric machine A; *i.e.*, from 8·45 to 11·5 hours through the wire coil of resistance *r*, and from 11·5 to 11·32 hours through the arc of an electric lamp producing the light J. The light of the lamp was not measured, but may have been equal to about 6,000 standard candles.‡ The first line was connected to the battery wire at 8·45 hours; the last line at 10·53 hours. The whole trial was completed at 11·32 hours.

The change from *r* to lamp (J) was made in so short a time that none of the out-stations noticed it. Messages were sent and received in the usual regular style.

Mr. C. B. P. Gordon, the superintendent of the Bengal Division, attended at the Signal Office.

At the beginning of the experiments, the resistances in circuit were measured.

Internal resistance of dynamo-electric machine A.	$m = 0·652$ internal	1·543 external	ohms at 85° F.
Wire coil $r = 1·517$			
Leading wire to tangent galvanometer.	$l = 0·026$		

After the experiments were over, these resistances were not measured again; however, on account of the very considerable heating by the strong main current, they must, we know, *all* have increased considerably.

* The small numbers in the form of exponents mean the number of observations made.

† $\frac{A}{E}$ main currents = 1·32. $\frac{A}{E}$ sent current = 1·55.

‡ When measured under 45° with the horizon.

* The three single earths measured gave : 7·7, 3·1, and 6·9 B. A. U.

† The dimensions are 4ft. by 2ft. and 1-16in.

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When r closed the poles of the dynamo-electric machine (8·45 to 11·5 hours) the mean speed of the engine was 60^{13} revolutions per minute; $\frac{\text{max.}}{\text{min.}} = \frac{64'}{56'}$; while the mean deflection of the main current was $37·87^{68}$; $\frac{\text{max.}}{\text{min.}} = \frac{40·25^{1}}{35·0^{1'}}$. When the lamp was in circuit (from 11·5 to 11·32 hours), the mean speed of the engine was again 60^{13}; $\frac{\text{max.}}{\text{min.}} = \frac{61}{59}$; while the mean deflection of the main-current was 44^{17}, $\frac{\text{max.}}{\text{min.}} = \frac{46^{2}}{42^{1'}}$.

In the following table all the results are given :—

TABLE SHOWING THE SENT AND RECEIVED CURRENTS AND OTHER PARTICULARS.

No. of Experiment.	Number and name of line and length in miles.	Real conduction resistance of line in b. a. u.	Resistance of Relay at receiving station in b. a. u.	Currents in milli-oersteds.		Mode of producing the currents.
				Sent at Calcutta.	Received at out-station.	
	2	3	4	5	6	7
I.	No. I Jubbulpore 738	4,412	905	6·18 9·81 5·89	4·00 7·60 4·45	100 cells Dyn.-el. m. A. 100 cells
II.	No. 4 Jubbulpore 803	5,795	406	7·07 10·23 7·41	3·60 4·71 3·50	60 cells Dyn.-el. m. A. 60 cells
III.	No. 5 Allahabad 577	3,075	492	9·81 13·79 9·41	6·50 8·57 5·08	60 cells Dyn.-el. m. A. 60 cells
IV.	No. 6 Sahibgunge 225	2,000	506	7·14 21·65 6·63	4·09 11·40 4·23	20 cells Dyn.-el. m. A. 20 cells
V.	No. 7 Cuttack 400	2,830	953	6·63 11·00 6·63	3·00 6·00 3·38	35 cells Dyn.-el. m. A. 35 cells
VI.	No. 8 Coconada 800	7,000	3,711	4·00 8·15 4·00	3·60 7·20 2·01	119 cells Dyn.-el. m. A. 119 cells
VII.	No. 9 Akyab 560	3,460	3,470	7·69 6·77 6·18	4·00 3·90 5·35	120 cells Dyn.-el. m. A. 120 cells
VIII.	No. 11 Dhubri	—	1,427	6·40 11·78 6·42	5·00 11·45 5·73	40 cells Dyn.-el. m. A. 40 cells
IX.	No. 10 Akyab 561	4,400	—	15·39 15·39 17·43	3·10 3·90 3·30	80 cells Dyn.-el. m. A. 80 cells
X.	No. 2 Agra 915	6,700	829	15·39 7·14 14·52	6·40 3·90 6·15	195 cells Dyn.-el. m. A. 195 cells
XI.	No. 3 Agra 850	5,800	1,959	13·54 13·38 9·41	3·25 3·10 4·14	100 cells Dyn.-el. m. A. 100 cells

REMARKS.—The several lines were connected to the battery wire in the order given in this table. The first line, Jubbulpore No. 1, was connected at 8·45 hours; the last line No. 3, Agra, at 10·53 hours. Before the actual experiments began, *i.e.*, before 8·45 hours, all the lines were tested for *sent currents* at Calcutta, and *received currents* at the out stations, when the usual signalling battery was on. Directly after each line had been connected to the battery wire of the dynamo-electric machine the *sent currents* at Calcutta and the *receiving currents* at out-stations were taken.

After the dynamo-current was stopped at 11·32 hour, and the batteries had been connected up again, the *sent currents* at Calcutta and the *received currents* at out-stations were again ascertained. Hence columns 5 and 6 contain three readings of *sent* and *received currents* for each line; first, with battery, secondly, with the dynamo-electric machine, and, thirdly, with the battery again. All the readings of the currents tapped from the main current of the dynamo-electric machine were taken between 8·45 and 10·53 hours, when the iron wire coil of resistance r was connected to the poles of the dynamo-electric machine. From 11·5 to 11·32 hours, when the lamp was substituted for r, no current readings at Calcutta and the out-stations were taken.

The main current of the dynamo-electric machine, when r was in circuit, was 36,801 m. ö; when the lamp was in circuit, 45,706 m.. ö*. From this it does not follow, however, that the tapped currents in the second case were larger than in the first, because it would also depend on the resistance offered by the arc, which is not known. The resistance of the arc, as more current was produced with the same speed of the dynamo-electric machine, must naturally have been smaller than $r = 1{,}517$ b. a. u. (iron wire coil), especially as there is an E. M. F. in the arc opposite to the E. M. F. of the dynamo-electric machine.

To produce 36,801 milli-oersteds through an external resistance of about 1·543 b. a. u., a total energy is consumed by the dynamo-electric machine of about 27,000 Ω ergs per second (representing about 3 h.-p. per second).

Conclusions.—These experiments show that it is perfectly possible and practicable to tap from the main current produced by a dynamo-electric machine *all* the signalling currents required at the Calcutta Telegraph Office. These currents were for the 11 lines connected up = 129·1 m. ö, if all keys were simultaneously and permanently sending. This represents only 0·35 per cent. of the main current (36,801 m. ö) with r in circuit, and ·28 per cent. of the main current (45,706 m. ö) with lamp in circuit. Further, it will be clear that such a small variation of the main current could not influence the regularity of any work done by that main current. In all the experiments the sent currents tapped from the main current of the dynamo-electric machine were considerably larger than when produced by the large batteries at present in use. Experiments IX. and X. only form an exception. However, I think these exceptions are in both cases due to errors of observation, because the battery readings in Experiment IX. do not all agree. The dynamo-current readings in No. X. must be wrong, because in No. XI., for a total circuit resistance of 7,759 units, the sent current is 13·38 m. ö, while in No. X., for a total circuit resistance of 65·29, the sent current is only 7·14. The error of observation is, therefore, obvious.

That with such strong received currents as are produced when the dynamo-electric machine is used the lines should work well is not to be wondered at. But it was also confirmed by the out-stations having to adjust their relays much more unsensitively.

Supposing now that we had useful work *day* and *night* for the strong main current, and that on the whole the new method could be always depended upon, I believe these experiments have proved that the signalling currents required in telegraph stations could be had for *nothing*, and that the method would be quite practicable.

The useful work for the main current at night would most conveniently take the shape of an electric light to illuminate very efficiently the signal office. The electric light, besides being more powerful, would possess the additional advantage of being produced by at least fifty times less heat than if the same light were obtained by combustion. This is no doubt a great advantage in a hot climate. During the daytime, I would use the main current for pulling punkahs, lifting messages, or, more generally, for working a pneumatic system of sending and receiving messages, &c. If Calcutta had the good fortune to possess a colder climate, it might be suggested that the heat developed in the coil of wire should be used for warming rooms. It would then only be necessary to lead the wire along the walls, in a manner similar to that in which hot-water pipes often are for heating rooms; the electric method being only far more economical. The heat given up by the wire, after dynamic equilibrium of the system has been established, is quite regular, and the method is obviously exceedingly clean and very convenient for domestic purposes. The wire attained its constant temperature of 93° C. after the current had acted for about half an hour, the air of the room having a temperature of 30° C.

The heat given out by the wire is by no means small. For instance, in our case, the average current working through a resistance $r = 1·543$ b. a. u. was 36801 milli-oersteds. This represents work done at a rate of 20473 Ω ergs per second, and supposing the wire has obtained the constant temperature, this whole energy is developed into heat emitted by the wire into space at a rate of $\frac{20473}{42} = 488$ gramme-degree-centigrade per second. This is equal to the heat produced by an ordinary German stove consuming 6lb of coals per hour; supposing that the loss of heat when coals are burnt under a steam boiler is four times as great as when they are burnt in a German stove. It appears, therefore, that the heat developed by the wire would be sufficient to keep a moderately sized and ordinarily ventilated room at a comfortable temperature even when situated in the highest latitudes.

* Calculated by the formula: $e = 47330 \tan \alpha$ (m. o'').

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1881.

The attempt to compress the history of the development of the applications of electricity into two numbers failed, and we must try the patience of our readers again.

The future of the electric light seems to depend greatly upon the incandescent lamp. The year 1881 will be for ever memorable in the annals of electric progress from the circumstance that in that year electric lighting by incandescence came into existence as a commercial and public reality. Our countryman, Mr. Swan, had in the previous autumn astonished the world with his lectures and experiments, first at Newcastle, and subsequently before the Society of Telegraph Engineers. We confess that the many failures of previous investigators, and the public and private information that we had about incandescent lighting, had created a feeling in our minds that to obtain anything good in that direction was almost a hopeless task. The successes of Mr. Swan revealed facts which had till then been overlooked by most electricians. We must not forget that, contemporaneously with Mr. Swan, Mr. Edison was attacking the problem, and some of his investigations made clear what had previously been, to say the least, rather mystical. We refer to the experiments made by Mr. Edison upon certain metals at a high temperature in vacuo. The full value of these experiments is even now scarcely realised by the great mass of investigators, but the paper read two years ago before the American Association for the Advancement of Science will become classic. The problem of incandescent lighting was no longer to be solved upon the old data. A new departure was taken, and careful investigation soon proved that what had been deemed impracticable was about to be realised.

In the spring of 1881 a company was formed by Mr. Swan's own townsmen to enter upon the manufacture of his lamp. The fitting up of workshops and the organising of a new manufacture of necessity occupies time, but Mr Swan, aided by his *collaborateur* Mr Stearn, proceeded energetically with the work, and in the autumn various installations of these lamps showed that the organisation, if not perfect, was sufficiently so for the rapid manufacture of the lamps. During the whole of the time the inventor was continually experimenting, and we understand with the result that the lamp has for some purposes been modified in form and very much improved. Although at the risk of some repetition we may mention the following installations of these lamps. The Savoy Theatre (1,200 lamps), the British Museum, the rooms of the Royal Society, the editor's room at *The Times*, the house of Mr. Spottiswoode, President of the Royal Society, at Coombe Bank, the saloon of the Mansion House, at the collieries of Risca and Earnock, at the residence of Sir W. Thomson, and in the following steamships:—"City of Richmond," H.M.S. "Inflexible," the "Servia," the "Alasca," the "Coptic," the "Arabic," &c.

Whilst, however, we naturally look upon Mr. Swan as the English apostle of incandescent lighting, we cannot but acknowledge that his great American competitor bids fair to claim no inconsiderable portion of the credit due to the pioneers of electric lighting. Endowed with a physique which seems to laugh at fatigue, and a plodding perseverance which amazes all who trouble to consider it, spending money with a lavishness little realised to try each and every conception and combination that flashes across a brain accustomed by long training to think into the very centre of the matter in hand, Edison has, through good report and through evil report, worked steadily onwards towards the goal he set himself to reach.

The year 1881 has been to him principally a year of preparation, and the value of this preparation will be ascertained in 1882. Already at Holborn we hear of private but successful trials. In New York the work of installing this light into one section of the city is rapidly approaching completion. One of the methods by which Mr. Edison has gradually approached success is by a system of exhaustive tests. In another issue we purpose to give diagrams showing the results of tests to obtain a good material for the carbon filament of his lamp. The examples illustrated are only a few among large numbers, but all of use to gradually reduce the materials in his hands that could be used till the best was found. Mr. Edison wished to devise not merely a lamp but a complete system. Probably he did not start with this idea, but his experiments led him to find that machines as well as lamps should be designed for the object in view. Professor Perry pointed out in his lecture before the Society of Arts that economy was to be found in large machines. Mr. Edison is building large machines. Sir W. Thomson, at the British Association, showed the relation that should exist between the internal and external resistances. Mr. Edison points out that his machines are designed with the view to obtain a somewhat similar proportion to that indicated by the greatest living authority.

We have previously mentioned the Maxim lamp in our review of the work of the Electric Light and Power Generator

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Company. The Lane-Fox lamp is in the hands of the Brush Company. It is in use in the Reading Room and part of the Science and Art School at South Kensington, in the shops of Messrs. Dick, of Holborn, and Messrs. Strode and Company, Cockspur-street, and at the Marquis of Salisbury's house at Hatfield. It is used by Messrs. Bullock and Company in India, by Messrs. Cardinosa in Spain, and various other places. The work with both these lamps has been for the most part preparatory. They will become better known in 1882, as will those of FitzGerald and of Crookes.

Of the semi-incandescent lamps, the Joel lamp has been installed at the Prudential Office in Holborn, in woollen mills in Yorkshire, at Ventnor, and the owners, Messrs. Rowatt and Fyfe, have various orders on hand for home and export. The Pilsen lamp, which also belongs to this Company, is in use in a large paper mill in Kent, where twenty lamps are installed. It is also used at the Institution of Fine Arts, Glasgow, as we ought to have mentioned when referring to this Institution in an earlier part of this review. The lamp is also in constant use at Messrs. Wells and Company's, Shoreditch.

Electrical Storage.—We shall now briefly allude to *the* event of the year so far as the electrical world is concerned, for, whatever may be said to the contrary, the solution of the problem of electrical storage means the revolutionising of the present methods of lighting. Gas and oil for lighting purposes will be comparatively quickly replaced by a better light if an economical system of storage is discovered. With the exception of a paper by Professor Gladstone and Mr. Tribe, which, owing to the extreme pressure on our space, we have been compelled to defer, we have kept our readers familiar with whatever has been published on this question. M. Planté's work in connection with secondary batteries is well known, and in May and June of 1881 letters over the signatures of "F.I.R.S." and Sir W. Thomson directed attention to M. Faure's modification of Planté's battery. Our own investigations in this direction have brought the conclusion that, of the secondary batteries obtainable, viz., those of Planté, Faure, and De Meritens, the Faure is, on the whole, to be preferred. If time is of importance, there can be no question about the matter. Faure's is the only one to be ready on an emergency. A number of patents for secondary batteries have been taken out, but nothing yet published supersedes Faure. The value of the unpublished patents is an unknown quantity; but we have had the opportunity of witnessing a large number of experiments, many with batteries said to be superior to Faure's; but, then, who ever knew an inventor who was not sanguine? The value of the various inventions, and we may especially mention those of Brush (which we presume are patented in England by Mr. Sellon), of Crompton, and FitzGerald, and of Mr. Swan, will only be known when tried on a large scale. The position of storage in 1881 is similar to that of incandescent lighting in 1880, the most that can be said is that it is not proved practically.

Telephones.—The progress made by the telephone during the past year has been extraordinary, and we may look for even greater advances in 1882. Men of business generally have made great use of it, and we suspect that no one who has tried it would willingly be without it. The various telephone companies have made numerous improvements in their instruments and systems, and introduced innovations, all tending to benefit their subscribers, the result being that this beautiful little instrument has found great favour in the eyes of the public generally. We may state here that a telephone has been lately invented which will permit of the use of as many as twelve, or even more, telephones on one wire. This will be shown at the Crystal Palace Exhibition. The fact of being able to use one wire for several telephones, without fear of the messages being mixed, is of great importance in the telephonic world. Even now, however, despite its increasing popularity with business men, we are far behind the Americans in making use of the telephone. Private individuals in this country do not yet seem to appreciate its utility. Perhaps the present year will witness the more extended use of the telephone by the upper classes, who can well afford the small annual subscription asked by the telephone companies, and who, having once ascertained its usefulness, will not like to return to the old state of affairs again.

In reviewing the work of the various telephone companies during the past year, we shall first glance at our own metropolis, and then take our readers further afield.

The United Telephone Company, which is now some two years old, has erected a number of new lines during the past year. It has now 16 exchanges, including the central one at 36, Coleman-street, E.C., which are situated as follows:—Leadenhall-street, Cornhill, Queen Victoria-street, Eastcheap, Chancery-lane, Westminster, South Kensington, Regent-street, East India-avenue, Hop Exchange, Eastern, Millwall, London Docks, Stratford, and the Victoria Docks. Some idea of the progress the Company is making may be gathered from the number of new subscribers coupled up to their system during the last four months, which is as follows:—In September 58, October 77, November 84, and December 50. During the last Session of Parliament *The Times* newspaper used the company's system to transmit the speeches of the members of the House of Commons from Westminster to Printing House-square, thus saving time and labour. The proprietors of *The Times* have been so pleased with the working of the wire erected for them, that they have since ordered another one. The company's rooms at Chancery-lane and Westminster have proved of great use to the members of the legal profession, by enabling clerks and others attending cases in the Law Courts and at Judges' Chambers to communicate direct with their own offices—a great desideratum in a case where papers may be required which they do not happen to have with them. The company is, we believe, arranging for the opening of rooms in the new Law Courts and the Guildhall, as well as some of the principal stations of the underground railway They also hope shortly to have lines working between Liverpool, Manchester, and London. License to connect London and Brighton has already been granted by the Postmaster-General.

The Telephone Construction and Maintenance Company, as its name implies, is a manufacturing company only, undertaking, in addition to the manufacture and supply of the telephones and electric apparatus generally, the erection and maintenance of lines. The principal work of this company since it was formed has been the erection and fitting up of their factory in Farringdon-road. The company are about bringing out a new combination telephone when their factory is in a fit state for manufacturing.

The India Rubber, Gutta Percha, and Telegraph Works Company has done a good deal of telephonic work in 1881, the quantity of which may be estimated when we say that its value amounts to something like £10,000. The whole of this work has been turned out under the very able superintendence of Mr. Foster, a son of the late Mr Le Neve Foster, well known prior to his death as the secretary of the Society of Arts.

Passing now to the country, we have again to record great

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progress in the use of the telephone. Lines have been erected by the Post Office in several of the larger towns, and in others private firms or companies have done so under license from the Post Office. Amongst the longest lines that have been erected we may mention that between Liverpool and Manchester, erected by the Government quite recently. This line consists of two wires, in order to overcome as far as possible the effects of induction, and is about forty miles long. The other was erected by a private firm, Messrs. Moseley, of Manchester, and runs between that city and Oldham. The Moseley patent transmitter is used on this line. It is a private wire, being the property of the *Oldham Evening Express*, a local newspaper.

In Sheffield the introduction of the telephone has been taken up *con amore* by Messrs. Tasker and Sons. The instruments in use are Johnston's patent transmitter, in combination with Bell's receiver. This transmitter was described and illustrated in *The Electrician*, Vol. VII., p. 150, and we are glad to be able to record the fact that the favourable opinion we have expressed of this instrument has since been amply borne out by the demand that has been made for it, and the satisfactory results that have been obtained with it in competition with other instruments. Messrs. Tasker's Telephone Exchange occupies an unique position amongst exchanges as to its rapid growth, smoothness of working, and its real practical utility to the commercial classes of Sheffield. At the end of last year the number of "calls" were 2,000 per week. At the present time the number of calls average 7,000 per week. Private telephone wires have also been extensively erected by this firm in Sheffield, and the Midland Counties generally, some of the lines being over 10 miles in length.

The Lancashire Telephone Company have established themselves in the county from which they take their name during the year, and have several exchanges working.

At Preston in the same county, Mr. G. Sharples has established an exchange, besides carrying out the work of connecting the fire stations at Burnley by telephone.

Bolton, a neighbouring town, also has its telephone exchange.

At Middlesbro' telephonic communication between the various fire stations has been established by Messrs. Harrison, Cox, Walker and Co. of Darlington. The same firm have also fitted up two ships with their instrument, the Hunning's micro-telephone, viz., the "Gloucester City," and the "Brooklyn City," sister ships built by Messrs. Richardson and Co., of Stockton-on-Tees.

A telephone line has been erected between Newport and Cardiff in Wales, and an exchange has also been established at Swansea, at all of which places many subscribers have been obtained. In addition to the towns we have mentioned, there are many others where local exchanges have been formed by the United Telephone Company, the National Telephone Company, and the Post Office, or into which the telephone has been introduced by private firms during the past year.

Perhaps the telephone has made as much progress in Glasgow and its immediate neighbourhood as anywhere, excepting London. The most notable event has been the uniting of the various competing telephonic interests in the spring of the year, by the purchase, on the part of the National Telephone Company (Limited) of the Bell and Edison systems, and by the amalgamation of that company with the extensive exchange and private systems of Messrs. D. and G. Graham, Mr. David Graham joining the local board of directors of the National Telephone Company (Limited), and becoming sole contractor for their work in the west of Scotland. Since the month of May last, when the above coalition was effected, the progress made has been great, the business of the National Telephone Company being more than fifty per cent. greater at the end of the year than at that period, and is continuing to increase in an even greater ratio.

The company have now about 500 exchange and 200 private lines in operation. In Glasgow they have four exchanges, and in Paisley and Greenock one each. These latter towns are also now about to be brought into direct communication with Glasgow by trunk lines. This, indeed, would have been effected a considerable time since had it not been that the Postal Department has hitherto refused to permit telephonic inter-communication to be made between towns, save on such terms as practically prohibit the carrying out of the work. An arrangement has, however, at length been come to between the company and the Postmaster-General, and the towns named will shortly enjoy the benefits of telephonic connection with each other. The wires are now almost uniformly attached to iron overhead standards, and not to the roofs of houses direct. The instruments employed are nearly entirely of American make, Blake transmitter, hand telephone with exposed terminals and magneto generator, being the combination found to give the greatest practical efficiency. A considerable number of the stations are on the Law system, in which a separate calling wire loop is employed. The exchanges are kept open night and day, the day operators being young ladies, who perform their duties in a manner which proves their entire suitableness for the work.

Of the telephone companies that have been formed during the past year to supply our foreign dependencies, and whose head-quarters are in London, the chief is the Oriental Telephone Company, which was registered on the 4th of February last, with a capital of £300,000. This company was started to establish telephone exchanges and private lines in India, Ceylon, the Straits Settlements, Java, China, Japan, South Africa, Australia, New Zealand, Egypt, Turkey, Greece, Malta, and the Hawaian Isles. The progress made by the company may be recorded as follows :—

Egypt.—In Alexandria an exchange has been in active operation for some months past, the number of subscribers at present is between 50 and 60, and extensions of the lines are shortly to be made, which will greatly increase these numbers. The leading European bankers and merchants are at present the company's chief supporters, but it is confidently expected that a large number of the native merchants will become subscribers when they are more familiarised with the telephone and have had practical opportunities of testing its value. It is interesting to notice that the Khedive was amongst the first subscribers to the Alexandria Exchange. At Cairo a building suitable for a central exchange has been erected, and most of the needful material being on the spot, but a short time will elapse before the exchange is in working order. Promises of support have been received from a large number of the leading officials, merchants, and others.

India.—Licences have been received from the Indian Government to establish exchanges in Bombay, Calcutta, Madras, and Rangoon.

Bombay.—The lines are being erected as quickly as possible in this city, and the company expects to be in active operation there before the end of the present month. About fifty subscribers, comprising the leading European bankers and merchants, have already been secured, and there is no doubt many more will be added directly the exchange is

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opened. The better classes of the native populatiou in India are usually very ready to follow the European element when the utility of any invention or system has been demonstrated, and the company reckons upon a large accession of subscribers from this source wherever it may open exchanges in India.

Calcutta.—In this city construction is being actively proceeded with, and it is anticipated that the exchange will be opened about the end of the present month. More than seventy subscribers have already been secured, including almost all the leading bankers, merchants, &c.

Madras.—The telephone system has been successfully introduced in this city, and the company has received many promises of support. Construction here will commence at an early date.

Rangoon.—No active operations have yet been undertaken in this city, but the company's local agents inform them that their prospects of success are good. Within a short time steps will be taken to establish an exchange.

Kurrachee.—The company have applied for a Government licence here, and hope to establish an exchange shortly.

China.—The company's operations in this country have so far been confined to Shanghai and Hong Kong. At the former place permission has been obtained from the municipal government to establish an exchange, and work is to be begun at once. Shanghai is an extended place, with a large population, and the company's engineer there, who has had great experience in America, leads them to expect very good results.

Hong Kong.—The Government has given the company permission to establish an exchange in this city, and the agents report the prospects of success as very good. Active operations will be commenced within a short time.

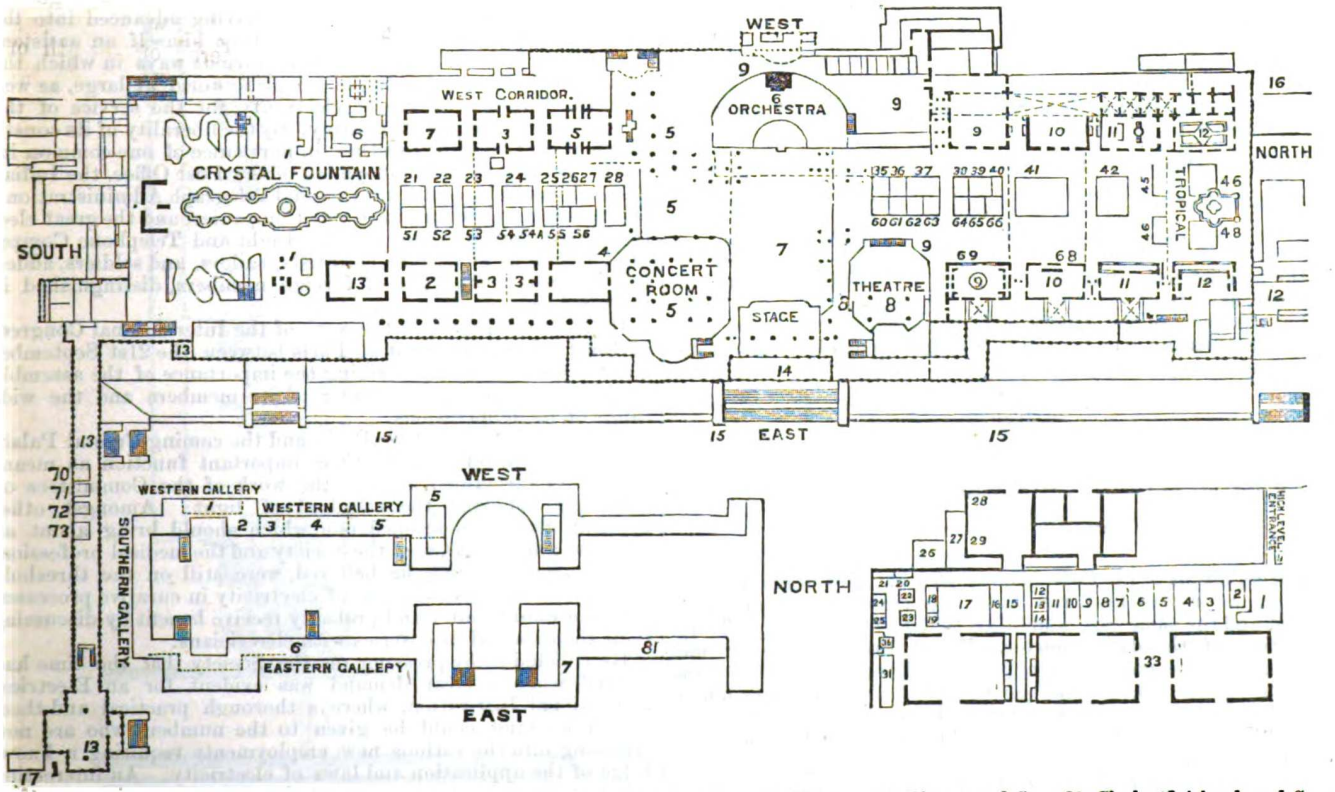
In some other places in the East the company has negotiations on foot of which it would be premature to speak in more than general terms at present, but which, it is believed, will terminate in results profitable to the company.

In Australasia and the Cape Colonies, owing to the attitude of the respective Governments, who themselves conduct telephonic businesses, nothing has as yet been possible, but negotiations are on foot which, it is expected, will shortly open a way for the company to commence operations in these countries.

Hawaian Isles.—In Honolulu the company has had the half interest in an exchange, which is returning a very large per centage of profit. It has 175 subscribers, and extensions are being made which, when completed, will add twenty-five more.

The Edison Gower Bell Telephone Company has very recently obtained a concession from the Portuguese Government for the exclusive right of working the telephone in that country, and the new year will probably witness its introduction there before it is many months old.

PLAN OF THE ELECTRIC LIGHT, &c., EXHIBITS AT THE CRYSTAL PALACE.



Nos. 1, 17, 21, Siemens Bros. and Co. (Siemens Frères, Paris); 2, 3, 22, 27, J. G. Lorrain; 3, 6, A. Gravier; 4, 8, 28, Strode and Co.; 5, T. A. Edison; 4, 6, Rowatt and Fyfe; 3, 7, R. E. Crompton and Co.; 6, 8, 9, 53, Compagnie Générale d'Electricité; 9, British Electric Light Company; 10, National Electric Light Company; 11, Electric Light and Power Generator Company; 12, 16, Anglo-American Brush Electric Light Corporation; 7, 13, 17, The Hammond Electric Light and Power Supply Company (Limited); 14, A. J. Fyfe; 8, 15, André; 1, G. Hawkes and Co.; 4, Swan's Electric Light Company; 5, White House Mills Company; 15, La Force et la Lumière; 30, Kelway; 31, Elmore and Co.; 32, Clark, Muirhead, and Co.; 23 and 49, Johnson and Phillips; 24, Telegraph Construction and Maintenance Company; 27, Macdonald; 41, H.M. Government (Postal Telegraph Department); 44, H.M. Government (War Office); 45, Consolidated Telephone Company; 46, Dolbear and Buck; 51, E. Paterson; 52, Monnier; 54, Eastern Telegraph Company; 55, Exchange Telegraph Company; 56, Dr. Gladstone; 61, Sir W. Thomson; 63, Submarine Telegraph Company; 67, Skrivanoff; 68, School of Submarine Telegraphy; 69, Cromwell Varley; 70, Sykes and Co.

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ELECTRIC LIGHTING.

The Economy of Electric Lighting by Incandescence.

By John W. Howell, Student at the Stevens Institute of Technology.

(*Continued from page* 126.)

Test by Voltameter.—Before making the test the generator was run for some time to allow the circuit to heat up, and the resistance of the line measured from time to time, until it was found to remain constant. The voltameter was then introduced into the circuit and allowed to remain fifteen minutes. During this time the speed of the dynamometer was determined for ten minutes and the average speed computed. The deflection of the pendulum was observed every three minutes and the average taken, although the variation was only one degree. At the end of the test the circuit was broken, and the resistance again measured, and it was found not to have changed perceptibly. The plates were then removed, washed in water, then in alcohol, and dried in a gentle heat. They were then weighed carefully.

Data obtained from the test :—

Weight of copper gained by negative plates, 24465 m. g.
Time of test, 15 minutes.
Weight gained per second, 27·183 m. g.
Average speed of dynamometer, 400·5 rev. per minute.
Average deflection of pendulum, 42 deg. 20 min.
Resistance of iron wires, ·76 ohm.
Resistance of iron wires and magnet coils in multiple arc, ·744 ohm.
Total resistance of circuit, ·744 + ·029 = 773 ohm.
Internal resistance of armature, ·016 ohm.

Results obtained from data :—

Value of current in webers, $\frac{27\cdot183}{\cdot32456} = 83\cdot753$.

Electrical energy $(83\cdot753)^2 \times \cdot773 \times 44\cdot24 = 239880\cdot726$ foot-pounds per minute.

Energy indicated by dynamometer, 171·2 × (sin. 42deg. = ·67344) × 400·5 × 6·2832 = 290125·54 foot-pounds per minute.

Friction of dynamometer and generator, 290125·54 × ·135 = 39166·9479 foot-pounds per minute.

Energy used in turning armature in field of force, 290125·54 × 865 = 250958·59 foot-pounds per minute.

Friction of dynamometer alone, 290125·54 × ·109 = 31623·68 foot-pounds per minute.

Energy actually applied to armature pulley, 290125·54 × ·891 = 258501·96 foot-pounds per minute.

Of the total electrical energy $239880\cdot7 \frac{\cdot016}{\cdot773} = 4965\cdot188$ appeared in the armature,

$$\frac{\cdot744}{\cdot773 \times 49\cdot68} \times 239880\cdot726 = 4647\cdot37$$

in the magnet coils, and 230268·176 foot-pounds per minute in the external circuit.

The efficiency of the generator is the ratio of the energy required to turn the armature in the magnetic field, to the total electrical energy developed,

$$= \frac{239880\cdot726}{250958\cdot59} = \cdot955.$$

The commercial efficiency is the ratio of the energy required to drive the machine (including friction) to the electrical energy which appears in the external circuit :

$$= \frac{230268\cdot167}{258501\cdot96} = \cdot8608.$$

Test by means of the Calorimeter.—As in the voltametric test the generator was first run until the circuit was thoroughly heated and the same care was taken to determine the speed and deflection of the dynamometer. When the calorimeter was thrown into the circuit an approximately equal resistance was thrown out so as not to change the total resistance too much. At the end of the test the resistance of the circuit was measured carefully as soon as the circuit was broken and before the wires became cooled.

Data obtained from this test :—

Water in calorimeter, 77lb.
Correction for waste heat, 178lb.
Range of temperature, 79 deg. — 69·8 deg. = 9·2 Fahr.
Specific heat for this range, 1·0015.
Average deflection of pendulum, 43 deg. 24 min. (sin. = ·68709).
Time of test, 16 minutes.
Resistance of iron wires and calorimeter coil, ·68 ohm.
This and magnet coils in multiple arc ·667 ohm.
Total resistance of circuit, ·667 + ·029 = ·696.
Resistance of calorimeter coil, 1 ohm.

Results obtained from these data :—

Energy developed in calorimeter,

$$\frac{78\cdot78 + 1\cdot10015 + 9\cdot2 + 772}{16} = 35022\cdot897 \text{ foot-pounds per min.}$$

Total electric energy,

$$35022\cdot897 \times 6\cdot96 = 243759\cdot36 \text{ foot-pounds per minute.}$$

Energy indicated by dynamometer,

$$171\cdot2 \times \cdot68709 \times 394 \times 6\cdot2832 = 291201\cdot46 \text{ foot-pounds per minute.}$$

Energy used in turning armature in field of force,

$$291201\cdot46 \times \cdot865 = 251889\cdot265 \text{ foot-pounds per minute.}$$

Energy actually applied to armature pulley,

$$291201\cdot46 \times \cdot891 = 259460\cdot5 \text{ foot-pounds per minute.}$$

Of the electrical energy,

$$243759\cdot36 \times \frac{\cdot016}{\cdot696} = 5603\cdot66.$$

appeared in the armature;

$$243759\cdot36 \times \frac{\cdot667}{\cdot669 \times 54\cdot41} = 4215\cdot89$$

in the magnet coils; and 233939·81 foot-pounds per minute appeared outside.

$$\text{Efficiency} = \frac{243759\cdot363}{251889\cdot265} = \cdot967;$$

$$\text{Commercial efficiency} = \frac{233939\cdot81}{259460\cdot5} = \cdot901.$$

(TO BE CONCLUDED.)

THE SOCIETY OF TELEGRAPH ENGINEERS AND OF ELECTRICIANS.*

On Thursday night the Society of Telegraph Engineers and of Electricians commenced their session with an inaugural address, at the Institution of Civil Engineers, from their newly-elected President, Lieut.-Col. Webber, Royal Engineers. The gallant officer congratulated the Society on having advanced into the second decade of existence. He had been himself an assistant at its birth in 1870. He recited the various ways in which the Society had been useful to the scientific world at large, as well as to the State, in its use of electricity, for the service of the telegraphs, the navy, and the army. By the liberality of its constitution it had brought together, in pursuance of one common interest, persons in the employment of the Post Office, the Indian Government Telegraphs, the Colonial Telegraph Administrations, the Railway and Submarine Cable Companies, and the great electrical manufacturers, the Electric Light and Telephone Companies, as well as physicists, scientists, sailors, and soldiers, added to which was a long list of foreign members, distinguished in the same line.

He mentioned some of the work of the International Congress of Electricians which sat at Paris between the 21st September and the 6th October, describing the importance of the assembly by the representative character of its members and the wide range of its deliberations.

He alluded to the late Paris and the coming Crystal Palace Exhibitions in reference to their important function as means of public instruction; also to the work of the Committees on lightning rods and the standard of light. Amongst other applications, he mentioned one which should bring about an intimate alliance between the Society and the medical profession, the members of which, he believed, were still on the threshold of science as regards the use of electricity in curative processes, and who would confer and probably receive benefit by discussing their theories and discoveries with electricians.

He concluded by pressing on the Society that the time had arrived when a clear demand was evident for an Electrical Educational Institution, where a thorough practical and theoretical training could be given to the numbers who are now crowding into the various new employments requiring a knowledge of the application and laws of electricity. An interesting reference was made to the labours in electricity and magnetism of Dr. Gloesner, once Professor at the University of Liege. His works were comparatively unknown in this country, and this opportunity was taken of rendering tribute to his memory by mentioning some of his early researches since 1822, described in his manuscripts exhibited at the Paris Exhibition.

* Abstract of the inaugural address of the President, delivered on Thursday, January 19th.

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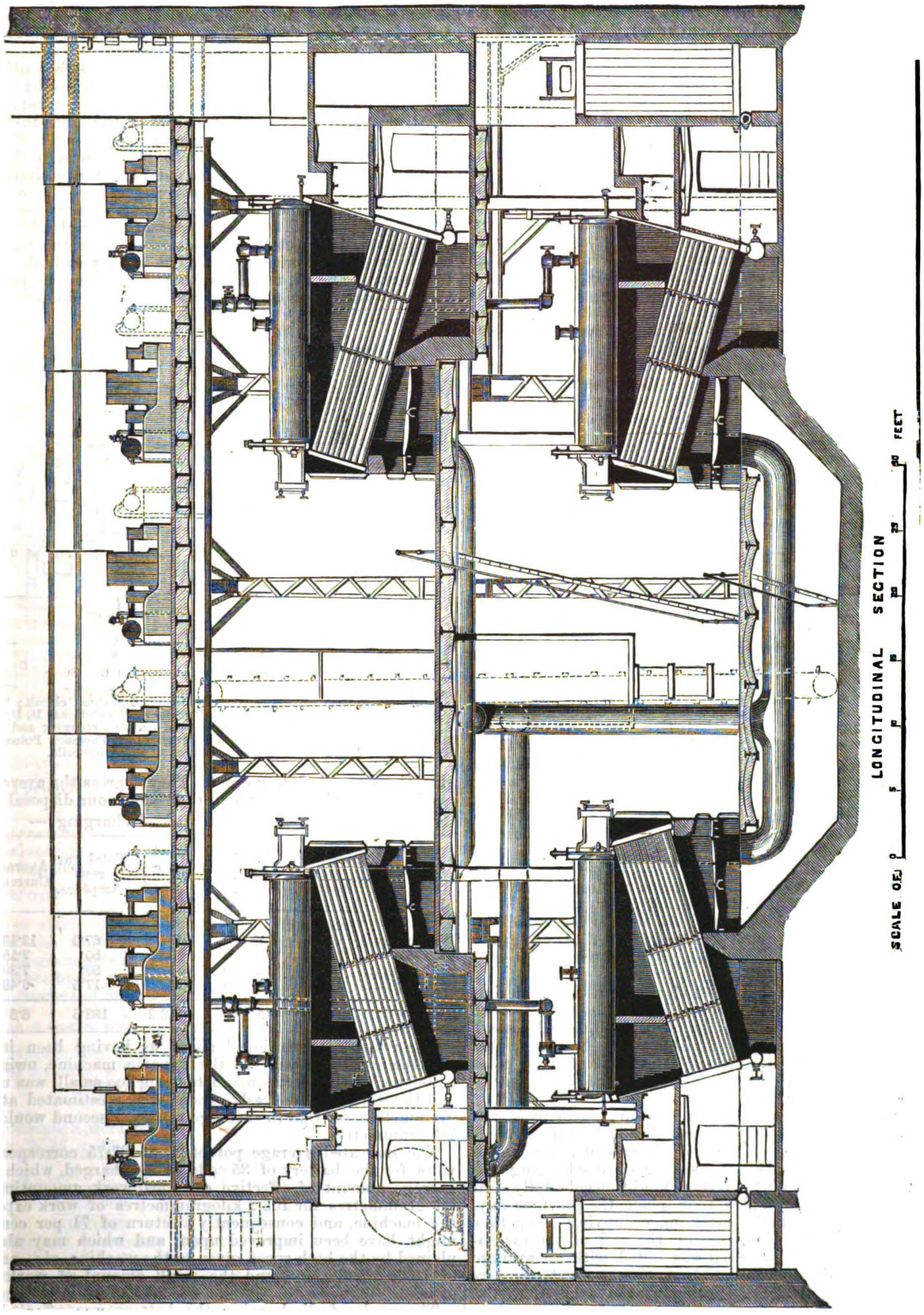
THE INSTALLATION OF THE EDISON LIGHT IN NEW YORK.



In our issue for January 7 we gave a plan of that part of New York which Mr. Edison has undertaken to light. His apparatus is, we understand, arranged in two adjacent houses taken for this purpose, these being Nos. 255 and 257, Pearl-street, New York, with a frontage of 25ft. and a depth of 100ft. Herewith we give a longitudinal section showing the arrangement of engines and dynamo machines. The engines used are those known as the Porter-Allen fast-speed engine, but of these and the machines we shall speak more particularly when we describe the arrangements at 57, Holborn. The illustration explains itself. We may call attention, however, to the use of the dynamo for the driving a blower to obtain the necessary air supply.

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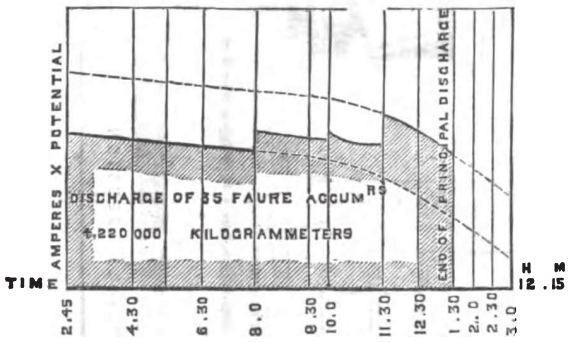
THE FAURE ACCUMULATOR.

Some very interesting experiments were carried out a few days ago at the Conservatoire des Arts et Metiers at Paris with Faure accumulators. The fact that these experiments were carried on under the sole direction of the Experiment Committee of the Electrical Exhibition gives them an additional value. They lasted over five days and more, during which time the capabilities of the accumulators to store up energy and do work were thoroughly examined. It will be seen by the figures and results of the experiments given hereafter how closely they approach the description of the battery given some months ago by the eminent electrician, Sir William Thomson.

The members of the committee mentioned above who personally assisted in the experiments were—Messrs. Tresca, (president), Potier, Joubert, and Allard, aided by Mr. G. Tresca. Mr. Gerard watched the experiments on behalf of Mr. Belpaire.

The accumulators, of which there were 35, were of the type known as "Laboratory," they were of round shape, the outer jar being of stoneware. The dimensions were :—external diameter 25 centimetres, total height 35 centimetres, total weight with water about 30 kilos (66lbs.). The electrical resistance of this type is somewhat high, and this gives rise to a loss of potential both in charging and discharging which will not occur in the batteries for industrial purposes of similar type to those used on tramways, and which require the charging and discharging to take place in a relatively short space of time. It is interesting to learn the reason for this difference, since it enables us to reconcile the results of experiments of apparently opposite characters.



Our readers probably know that the Faure accumulator, unlike all known secondary batteries, consists principally of two conducting bases, on which are applied the materials which by the subsequent process of formation are to become the active agents—for instance, oxide of lead, spongy lead, &c.; whilst M. Planté's battery, to take an example, is rendered active by the disintegration of the same plates which in M. Faure's battery are merely supports or bases.

Again, M. Faure having ascertained that the surface of these supports, whilst they have a great influence on the resistance of the battery, have none on the capacity for storage, this depending solely on the thickness of the spongy lead which he applies to the surface of the supports, and as all these are allied to the question of cost the formation of types with large and small resistances has followed.

The round-shaped accumulators which we are now considering were formed of two plates rolled in a spiral. The positive—that is to say, the plate which carried the negative terminal—was 1 millimetre thick, and the negative 2 millimetres; both were perforated with holes of 1 centimetre diameter, and they were covered on both faces with a layer of minium (red lead) in the proportion of 10 kilos to the square metre.

We herewith give a diagram showing the arrangement of the instrument used in this experiment, which was begun on Wednesday, the 4th of January, at 10 a.m. Meanwhile, previous to this, a preliminary experiment, consisting of discharging the batteries of any electricity which they might accidentally contain, had been carried out. This took place the previous day, and also during a part of the morning, occupying altogether about six hours, during which, towards the end of the experiment, the decrease of the potential was noted, with an average current, taking as unity the potential at the two extreme terminals of the 35 cells in series, noting at the same time the luminous intensity.

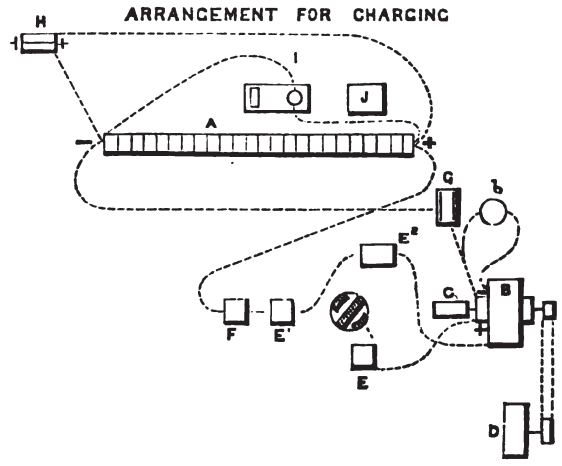
This experiment was necessary from the fact that it was not required to measure the total capacity for storage, but this capacity, or, rather, this result between practical limits, during which the lamps should give a uniform and satisfactory light. These preparatory measures give the limit of the experiment, which was also very well determined at its finish by the rapid decrease in the luminous intensity.

As the figure given below shows, motion was transmitted to the Siemens machine through an intermediate dynamometer, the readings of which, calculated according to the ordinary measures, are given in the following table. The Siemens machine being constructed to produce a less high potential than that obtained, it was necessary to introduce a resistance in the exciting current, which, not being absolutely a necessity in the system, should be deducted from the total work expended.

The explanatory index below the figure sufficiently explains the different instruments. It will be enough to add that the deposit of copper in the weber meter G always corresponded with what was expected from the readings of the other instruments.

The electromotive force of an accumulator, when charged, was found to be 2·15 volts, and in reading the figures of the potential column obtained by Thomson's patent meter, it should be kept in mind that this number, 2·15, corresponds to 32·5; and also that these numbers, owing to the gradation of the instrument, are directly proportional to the tangents of the angles.

Some small corrections will be necessary in the figures which we give in the following tables; but as they will take some time to ascertain, and as, moreover, these results will be published by the committee, with all necessary details, we do not pretend to



A, Storage Battery; B, Siemens machine excited in shunt circuit; b, Resistance in the exciting circuit; C, Recorder of Number of Revolutions; D, Dynamometer; E, E¹, E², Deprez Galvanometer giving total current, charging and exciting; F, Siemens Electro-dynamometer; G, Webermeter; H, Thomson Potentiometer; I, Mascart Reflecting Electrometer; J, Battery of 42 Daniell cells.

give them as absolutely exact. They express the average of the results within the limits which the time at our disposal permits:

Table giving the work of charging :—

	Number of Hours.	Total work K *m*.	Work per second K *m*.	Total current Ampères.	Average Current.	Indicated Potential.
	H. M.					
Wednesday..	5 30	2420000	122	67·0	12·18	36
Thursday.....	7 0	2730000	108	50·	7·15	39
Friday.....	7 30	2920000	111	59·	7·89	39
Saturday.....	2 45	1130000	109	17·5	6·48	39
Average	22 4	9200000	112·2	193·5	8·5	37·75

The resistance mentioned above as having been introduced into the exciting circuit of the dynamo machine, owing to the resistance of the electro-magnets being too small, was measured, and the work thus uselessly expended was estimated at 10 kilogrammetres, so that the average work per second would be 102·2 kilogrammetres.

The indicated average potential of 37·75 corresponds to 87 volts for the battery of 35 cells being charged, which gives an average amount of effective electrical work amounting to 74·5 kilogrammetres for 102·2 kilogrammetres of work expended by the machine, and consequently a return of 71 per cent., which might have been improved upon, and which may also be explained by the high speed given to the machine, viz., an average of 1,060 revolutions, and the small amount of work required of it.

The work of discharging the battery was effected at two operations, with an interval of 36 hours between them. It was begun at 2·45 on Saturday the 7th of January, and continued up to 10 o'clock the same evening; taken up again on Monday morning at 10 o'clock, and finished at 3. It was, however, virtually finished at 1:30, according to the luminous and other indications, such as are alluded to at the beginning of this article.

During the discharges the desire to imitate that which takes

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place in practice, and the object of which is to render the work given out, for lighting or other purposes, uniform, introduced a certain small amount of confusion, if we may so express ourselves; but, if the theoretic study of the question may have suffered a little, the practical results obtained are most interesting and important.

In the first place, 30 cells of the battery were discharged, the other five being added in succession, with the evident object of rendering the results uniform. This was simply and satisfactorily effected by means of a commutator. The same thing was done in discharging the second time, passing successively from 30 to 32 cells, and then to 35.

It is very easy to gather from the calculations what would have been the curve of this discharge, if, for instance, the whole thirty-five cells had begun to be discharged at once. The dotted lines in the figure show this.

During the discharge the arrangement of the instruments was the same as for charging. There were, in addition, eleven Maxim lamps, one of which was placed in a dark closet with the committee's photometric apparatus, and which was under the care, sometimes of M. Allard and at others of M. Leblanc. Here, again, we consider it right to say that the figures in the following table have nothing absolute about them; they are subject to different small defects, but they give averages which are closely allied to the absolute results which will be obtained with certainty.

The number of readings were much greater than our space permits us to reproduce.

Table of the work of discharging 35 Faure accumulators through eleven Maxim lamps :—

Time of the Day.	Current Ampères.	Indicated Potential.	Light Candles.	Remarks.
H. M.				
2 43	0	27·8	0	30 cells being discharged.
2 45	16·37	26·2	16	
4 30	16· 0	26·0	...	
6 30	15·68	25·5	...	
8 0	15·49	25·3	13	
8 5	16·70	27·2	17	32 Do.
9 30	16·24	26·5	...	
10 0	16·06	26·0	16	
10 0	0	28·5	0	32 Do.
10 15	16·82	26·9	17	
11 30	16·20	25·7	15	
11 35	17·74	27·9	20 (?)	35 Do.
12 30	16·42	26·0	17	
1 30	14·73	23·9	11	The principal experiment had been finished.
2 0	13·85	22·8	...	
2 30	13·26	21·9	...	
3 0	12·64	21·0	3	

Nothing remains to be added to these figures, which speak for themselves, save that the number of ampères-hours given out during the legitimate duration of the discharges was about 178, giving a current of $\frac{178}{193}$.

Five days after the charge and the work which forms the integral of the surface *hatchée* of the diagram amounts to 4,220,000 kilogrammetres.

On the other hand, we put into the battery a work represented by a mean current of 8·5 ampères per second during 22 hours 45 minutes, at a mean potential of $\frac{2{\cdot}15 \times 35 \times 37{\cdot}75}{32{\cdot}5}$ 87·5 volts, with an average current of 8·5 ampères per second during 22 hours 45 minutes, with a mean potential of

$$\frac{2{\cdot}15 \times 35 \times 37{\cdot}75}{32{\cdot}5}\ 87{\cdot}5 \text{ volts,}$$

which represents a work of

$$\frac{87{\cdot}5 \times 22{\cdot}75 \times 3{,}600 \times 85}{g} = 6{,}020{,}000 \text{ kilogrammetres,}$$

or a return by the accumulator of

$$\frac{4{,}220{,}000}{6{,}020{,}000} \times 100\text{c.} = 70 \text{ per cent.}$$

We ascertained previously that the return from the Siemens machine in the very bad conditions under which it was working was also 71 per cent., so that even under these circumstances the work returned in light amounted to nearly 50 per cent of the initial mechanical work.

To render the important experiment still more comprehensible, we would remark that the discharges represented an average work of 110 kilogrammetres per second during nearly eleven hours, and this was contained in a little more than 1,000 kilos weight of batteries.

VOLTAIC ACCUMULATION.

On Friday last Mr. Swan repeated his lecture on the above subject, given in our last issue, before the Literary and Philosophical Society of Newcastle. As Mr. Swan's second lecture contains much of importance that was not given in his former paper before the Chemical Society, we herewith reproduce a portion of it.

After alluding to the Faure and Planté cells, Mr. Swan said :—

"At a recent meeting of the Royal Society, a paper on a new electrical storage battery, communicated by Henry Sutton, of Ballarat, Victoria, was read. This paper describes various experiments in electrical storage, and speaks of the great effectiveness of an arrangement which is a sort of cross between Daniell's and Planté's cells. In Sutton's arrangement the copper plate and sulphate of copper solution of Daniell is retained, but used in conjunction with a plate of lead amalgamated with mercury, instead of a plate of zinc, amalgamated with mercury. The metals of the Daniell cell consist, as I have said, of a copper plate and a plate of mercurialised zinc. The metals of the Sutton cell consist of a copper plate and a plate of mercurialised lead—a very small difference in sound, but making a world of difference in the action of the cell—completely inverting its action, in fact—for in the Sutton cell the copper plays the part that zinc ordinarily plays, and the lead plays the part which copper ordinarily plays in voltaic cells. That is to say, the copper is the metal which, during the giving out of current by the cell, becomes oxydised, and is, therefore, the positive metal. In the Daniell cell it is the negative metal. Mr. Sutton says that in process of charging the cell the lead readily oxidises to a great depth, the peroxide forming a regular layer on the surface. From experiments I have made I can fully confirm Mr. Sutton's statement as to the facility with which a thick crust of peroxide forms on the mercurialised lead in his cell—giving it, as he says, large capacity of storage. The discovery of this means of rapidly forming a thick coating of peroxide is invaluable. It is to the large quantity of oxide of lead applied to the lead plates in Faure's cell that its great storage capacity is due; but to form the oxide out of the plate itself, as Planté does and as Sutton does, and as in another way I am able to do, is better than to apply the coating of oxide as M. Faure does—provided we can get a thick enough crust—and according to Mr. Sutton's method, and my own also, I have no doubt we can. While experimenting with Sutton's cell, I found a troublesome tendency in the copper deposit to spread and form a connecting link between the copper and the lead plates, which quite destroyed its efficiency. It therefore occurred to me to discard the copper solution and the copper plate after the coating of peroxide had been formed on the lead, and to use the oxidised coated lead plates alone with dilute sulphuric acid, as in Planté's cell. I therefore rearranged the oxidised plates in this manner, and I am glad to say I have obtained the most excellent results with the cell thus modified. The storage capacity is large, and the cell works well in every way. It is evidently possible to produce the oxidation of the mercurialised lead plates by means of copper solution—either before the plates are built into the form of cells, or while they are in that form—that is a mere matter of convenience in constructing the cells. While the subject of electrical storage of energy is occupying so large an amount of public attention, I think it is desirable to avail myself of this opportunity of publishing the results I have obtained with Sutton's cell, and also with the modification which I have described." Speaking of the possibility of lighting trains by means of incandescent lamps and storage cells, Mr. Swan said: "For lighting railway carriages I think the most feasible arrangement will be to have a small dynamo and set of store cells for each carriage. The arrangement for working the dynamo might be extremely simple. The armature might be attached to one of the axles of the carriage. Whenever the carriage moved there would be a current of electricity generated if the circuit were closed through the lamps and store cells. When the cells were full they could be thrown out of action automatically. The amount of power absorbed by the armature would be quite insignificant. The cells might be of such a size as to keep the lamps lighted for an hour or so after the carriage had come to a standstill. The same dynamo could be easily applied to store currents in another set of cells to be used for the working of an electro-magnetic brake, which might be of great power with very small abstraction of the motive power of the engine, for the principle of accumulation comes into play here most advantageously. Whether railway carriages and tram-cars are to be in future driven by electricity is not yet quite a settled question, but it is certain that whenever (if ever) they are so driven electric storage of energy will play an important part in bringing it about. Some people have the idea that by means of store cells we shall have portable electricity extensively employed. A daily supply of electrically-stored energy, delivered at your door like milk, the empty cells to be taken away at the time the full ones are brought. From what I have already said it is evident that this idea is not likely to be realised. There is no form of energy so easily conveyed to a distance as the energy of electricity, and to think about carrying it about in boxes instead of sending it on its distant and repeated journey through wires is to ignore and waste one of its most valuable properties. The probability is, that in every house lighted by electricity, and that I hope will soon be almost every house, there will be a fixed set of cells occupying a place, and perhaps also a space not unlike that which a water cistern occupies in a house. These cells will be in communication through insulated and hidden wires with a main central electric supply, and will either be kept charged by continual connection with the main—as our water cisterns are—and with a regulating appliance equivalent to the automatic feed of a water cistern, or the current will be turned on for a few hours each day until the cells of one district are fully charged, and then the current will be turned on to another district to charge the cells of that district. Where electricity is wanted for lighting during the hours of the dark, and for performing any kind of occasional and inconstant work, electric storage of energy leads to reduction in the size and cost of the motor apparatus for generating electricity, and does away with the necessity of keeping it in action during the whole time electricity is drawn off from it. If electricity is only required to be supplied during three or four hours each evening, engine power and dynamo power of one-half or one-quarter the size that would have been required without storage will be sufficient, and with the great advantage that if a small proportion of the electrical work extends over a longer period—say for keeping a few lights burning—it might be during all the twenty-four hours—although the

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engine and dynamo may have been in action during only the daytime, or even during only a part of the day—the stored electricity will be sufficient to give either light or power to the extent required wherever it may be wanted. Here is a piece of apparatus invented by Sir William Thomson, which enables storage cells to be used in conjunction with a dynamo-electric machine in such a way that there is no waste of motive power. By the automatic action of this apparatus the cells are kept constantly charged; while the current is not being drawn off the dynamo is thrown out of action, and when the current is used, power is absorbed in just sufficient amount to keep the store cells fully charged; or if the current is drawn off so rapidly that the dynamo cannot keep the cells fully charged, both machine and cells contribute current, and in that way, the cells and dynamo together, are able to do more in a given time than the dynamo alone could do—enabling us, in fact, to obtain the utmost advantage possible from the combination. It is impossible to fully realise the consequences that must follow from the combination of electrical storage of energy with the dynamo electric machine. The dynamo electric machine standing alone and unsupported by electric storage of energy, is truly a great power, largely tending to develop the practical use of electricity—but, in alliance with secondary voltaic action—the practical value of the dynamo electric machine is increased a hundred-fold. They are inseparable. Neither is complete without the other. Things that were impossible to be done with the unaided dynamo can now be easily accomplished by this combination. One of the results of the combination of the dynamo with store cells will be, that primary currents of higher tension than would have been convenient or safe to use directly can now be used in such a way as to entirely get rid of the danger and inconvenience of using such currents, and yet gain the full advantage of economical distribution of current from a central station over a wide surrounding area. But these advantages are not obtained without some sacrifice. In taking the electric current at second-hand through the store cells, instead of directly from the dynamo-electric machine, there is a waste of energy amounting to between 10 and 20 per cent. This is an amount of loss that we can well afford to bear for the many advantages electrically-stored energy gives us. We can, as I have shown, obtain electricity directly from heat; but so far, not economically, that is to say, an even greater loss—probably double the loss—which attends the development of motive power through the steam engine attends the development of electricity by the direct action of heat. Only about five per cent. of the actual energy stored in fuel is utilised in a thermo-electric pile. But there is every reason to hope that the thermo-pile may be improved—perhaps more than doubled in its efficiency—and whenever such an advance takes place then the thermo pile will occupy a useful place among apparatus for generating electricity for electric lighting and other purposes, and especially in conjunction with store cells. My attention was drawn to this point by Mr. Higgins, of London, who has worked with thermo-piles to a considerable extent. Mr. Higgins pointed out to me that one of the difficulties in connection with the use of thermo-piles was their liability to deteriorate through expansion and contraction incident to intermittent use. And he suggested that by combining store cells with a thermo-pile this difficulty could be completely avoided, the thermo-pile being made to act continuously on the slow-combustion stove principle, the store cells acting as an accumulator. With reference to the application of electricity to the production of motive power, at present we depend on motive power for the production of electricity. It is, therefore, a roundabout process to reproduce motive power from motive-power-produced-electricity. Still, there are cases in which the economy of producing motive power on a very large scale, and the facility with which this power may be subdivided and distributed by means of electricity, will make the reproduction of motive power in this roundabout way both economical and convenient; notably in cases where at no great distance from a town or populous district requiring motive power for industrial purposes there is some great stream or waterfall; and, in connection with electrical storage, it is within the scope of probability that the fitful power of wind and the intermittent power of tides may be made more practically serviceable in the development of motive power."

THE CUBA SUBMARINE TELEGRAPH COMPANY (LIMITED).

The twenty-first ordinary general meeting of this Company was held at the offices, 61, Old Broad-street, E.C., on the 18th instant, under the presidency of Mr. Thomas Hughes, Q.C.

The SECRETARY (Mr. James Scott) read the notice convening the meeting, and the report of the directors, which has appeared in *The Electrician*, was taken as read.

The CHAIRMAN, in moving the adoption of the report and accounts, observed that the half year had been a satisfactory one, for, while the expenses had remained almost at the figures at which they stood in the corresponding period of last year, the receipts had increased by over £1,000. That was a very satisfactory state of things, and he thought that the shareholders might be congratulated on the result. They proposed that a dividend should be declared at the rate of 6 per cent. on the ordinary shares, and, of course, of 10 per cent. on the preference shares. The only point on which he need make any remark as to the accounts was the appearance of the sum of £2,000 as half of the annual payment on account of the Cienfugos-Santiago cable. The shareholders would remember the arrangement by which the Company had bought this entirely new cable, which had been working admirably, for an annual payment of £4,000. The board thought that the payment might fairly be reckoned in considering the question of what should be carried to reserve. It had been their custom to recommend that a much larger sum than £1,000 per half year should be carried to the reserve fund—in fact, on an average, they had transferred £2,500 to it. They felt that this annual payment was a prudent recommendation, and that it was practically strengthening the reserve fund by the existence of a cable for which they were paying by instalments. He could not pass over in entire silence the announcement lately made in the Press that the American scheme of Jay Gould for laying new cables down the west coast of America, and also at Brazil, touching at the Bermudas, had practically come to a head. It was stated that the concessions had been obtained and that the contracts had been put out; but it remained to be seen whether this was true. Supposing it should be so, and the lines were successfully laid, of course the position of the Company would be affected. He alluded to the matter two years ago, and now it appeared to have taken much more shape. The board thought it right that the attention of the shareholders should be called to the public announcement which had been made. He did not think there was anything else on which he had to detain them. Their cables were all in good working order, and everything was going on highly satisfactorily. He concluded by moving the adoption of the report and accounts.

Mr. JOAQUIN DE MANCHA having seconded the motion,

Mr. GRIFFITH thanked the chairman for the clear statement he had made, and for taking the shareholders into the confidence of the directors as to Jay Gould and Company's new scheme. As a large shareholder he had taken great interest in the Company, and had gone through the Articles of Association. He had found that the auditor did not quite conform to the Article referring to the audit. Although, no doubt, everything was right in the accounts, he thought it would be as well if a second auditor were appointed, as it would, he held, give greater confidence to the shareholders and the public.

The CHAIRMAN, in reply, stated that it was open to the shareholders to appoint another auditor, and the board would be guided by their opinion. At the same time Mr. Cowan had served them from the first, and had always done his duty in an admirable manner.

Mr. JOHN NEWTON expressed his full appreciation of the manner in which the accounts were set forth. No other telegraph company published such complete and full details of their traffic, income, and expenses.

The CHAIRMAN then put the resolution to the meeting, and it was declared carried unanimously. Continuing, he moved the declaration of the dividends recommended.

Mr. DE MANCHA seconded the motion, which was carried unanimously.

Mr. GRIFFITH, in moving a vote of thanks to the chairman and directors, observed that the shareholders knew that those gentlemen had done their best for the Company for a considerable time, and were thoroughly well acquainted with its management. Of course they were not responsible for such matters as the laying of competing cables; and the shareholders ought to be ready to acknowledge the services they had rendered to the Company, and the excellent balance-sheet they had shown for the last six months.

Mr. NEWTON, in seconding the motion, said he thought that too much impression was produced in this country by Jay Gould's operations. That gentleman seemed to have his hands too much filled with telegraph schemes, and he thought he would possibly come to grief through them. The resolution was carried unanimously.

The CHAIRMAN expressed the acknowledgments of his colleagues for the compliment, and the meeting then separated.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices Jan. 18.		Business Done Week Ending Jan. 18. Highest.		Lowest.	
Anglo-American	49½,	50	.....	50	.....	48⅛
Do. Preferred	76,	77	.....	78	.....	76
Do. Deferred	21,	21½	.....	22	.....	20½
Brazil Submarine	11½,	11⅝	.....	11⅝	.....	11½
Cuba	9½,	10	.....	9⅝	.....	9⅛
Do. Preference	16,	17	.....	17⅛	.....	—
Direct Spanish	4⅜,	5⅛	.....	—	.....	—
Do. Preference	14½,	15½	.....	14⅜	.....	14⅜
Direct United States Cable	10⅜,	10½	.....	10½	.....	10½
Eastern Telegraph	10,	10½	.....	10½	.....	10
Do. 6 per Cent. Preference	12½,	12⅝	.....	12⅝	.....	12½
Do. 5 per Cent. Debentures, 1899	105,	108	.....	—	.....	—
Eastern Extension	10⅞,	11⅛	.....	—	.....	—
German Union	9⅛,	10½	.....	10½	.....	10
Globe Telegraph and Trust Company.	6⅛,	6⅜	.....	6⅜	.....	6⅛
Do. Preference	12⅛,	12⅜	.....	12⅜	.....	12⅛
Great Northern	11⅛,	12	.....	—	.....	—
Indo-European	28,	29	.....	29	.....	29
Mediterranean Extension	2⅛,	2⅜	.....	—	.....	—
Do. Preference	9⅛,	9⅜	.....	9⅜	.....	9⅛
Reuter's	12⅛,	12⅜	.....	12⅜	.....	12⅛
Submarine	285,	295	.....	288	.....	288
West India and Panama	1⅞,	2⅛	.....	1⅞	.....	1⅞
Do. 1st Preference	7⅞,	8⅛	.....	8⅛	.....	7⅞
Western Brazilian	7⅛,	8	.....	7⅛	.....	7 11-16
West. Union 7 per Cent. 1st Mortgage	123,	128	.....	—	.....	—
Do. 6 per Cent. Sterling Bonds	104,	107	.....	—	.....	—

TELEPHONES.

Consol. Telephone and Maintenance	1⅛,	1⅛	.....	1⅛	.....	1 5-16
Oriental	⅛,	⅛	.....	9-16	.....	9-16

ELECTRIC LIGHT.

Electric Light and Power	1⅛,	1⅛	.....	1⅛	.....	1⅛
Anglo-American Brush	9½,	10	.....	10⅛	.....	9⅛
United Telephone	11,	11⅛	.....	11⅛	.....	11⅛

TRAFFIC RECEIPTS FOR DECEMBER, 1881.

Companies.	Dec., 1881.	Dec., 1880.	Increase.	Decrease.
Anglo-American Telegraph Company	—	—	—	—
Brazilian Submarine Company	—	—	—	—
Cuba Submarine Company	£2,500	£2,494	£6	—
Direct Spanish Telegraph Company	1,459	1,520	—	£61
Direct United States Cable Company	—	—	—	—
Eastern Extension Telegraph Company	31,319	28,010	3,309	—
Eastern Telegraph Company	49,844	46,776	3,068	—
Great Northern Telegraph Company	16,720	—	—	—
Submarine Telegraph Company	—	—	—	—
Western and Brazilian Telegraph Company	—	—	—	—
West Coast of America Telegraph Company	—	—	—	—
West India and Panama Telegraph Company	—	—	—	—

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